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INSTRUCTION MANUAL
MODEL 110
40 Mc PULSE GENERATOR

(Partially Revised for Model 110A)

DATAPULSE

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MODEL 110
40 Mc PULSE GENERATOR

(Partially Revised for Model 110A)

This Manual has been fully revised as to Section III (Theory of Operation), and contains schematic diagrams which reflect changes incorporated in the Model 110A.

Fully revised text material for other sections, and a complete parts list will be automatically forwarded to you IF YOU COMPLETE AND RETURN THE POSTAGE-PAID "WARRANTY REGISTRY" CARD ATTACHED ABOVE.

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MODEL 110
40 Mc PULSE GENERATOR

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J40000-130	Schematic - Front End Model 110A
J40000-131	Schematic - Output Amplifier Model 110A
J40000-104	Schematic - Attenuator Model 110A
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SECTION I

SPECIFICATIONS

1.1 REPETITION RATE

Continuously variable from 4 cps to 40 mc, covered in seven decade ranges. Maximum rate on Double Pulse Mode is 20 mc.

1.2 EXTERNAL TRIGGER

Operates at 0-40 mc (20 mc maximum on Double Pulse Mode) from ±1.5v pulses with rise times less than 20 nanosec and duration greater than 20 nanosec (requires a greater amplitude for slower rise times or lesser duration). Sensitivity control is provided to allow adjustment for noise rejection. Input impedance may be selected by panel switch as 50 ohms or 500 ohms. Maximum dc level or transient amplitude which may be applied is ±25v with sensitivity control at maximum.

1.3 SINGLE CYCLE

Operation of a front panel pushbutton provides one cycle (single or double pulse, as selected) of output.

1.4 GATED OPERATION

External gate signal levels of +3.5v or more, block main pulse outputs but do not interrupt the Sync Output; no connection or levels of zero or less enable outputs. Input resistance is approx. 1000 ohms. Levels greater than ±25v may not be applied.

1.5 SYNC OUTPUT

Negative 4v from 50 ohms (2v into 50 ohms), approx. 20 nanosec duration, approx. 5 nanosec rise and fall time with 50 ohm load. Sync occurs approx. 100 nanosec after external trigger if used.

1.6 PULSE MODES

Single Pulse or Double Pulse, selected by panel toggle switch. In the Double Pulse Mode, two main pulses are provided at the output during each cycle (essentially identical in width, amplitude, polarity, rise time, and fall time). One Output appears approx. 25 nanosec after the Sync Output and the second at a position determined by the pulse delay controls.

1.6.1 Main Pulse Delay, Single Pulse Mode (of minimum rise time leading edge from Sync Output).

Continuously variable from approx. 10 nanosec advance to 50 millisec delay, covered in six decade ranges plus 10 to 50 nanosec range. Maximum delay duty cycle is typically 85%, decreasing to at least 50% at 30 mc and 40% at 40 mc repetition rate.

1.6.2 First Pulse Position, Double Pulse Mode

Minimum rise time leading edge occurs approx. 25 nanosec before Sync Output.

1.6.3 Pulse Separation, Double Pulse Mode

Leading edge of first pulse to leading edge of second pulse is continuously variable by means of Pulse Delay controls from 25 nanosec to 50 millisec. Minimum trailing edge to leading edge separation (at min. rise and fall times) is approx. 30% of pulse width or 15 nanosec, whichever is greater.

1.7 PULSE DURATION

Continuously variable from 10 nanosec to 5 millisec, covered in five decades plus 10 to 50 nanosec range. Maximum duty cycle is typically 85%, decreasing to at least 50% at 30 mc and 40% at 40 mc.

1.8 JITTER

Repetition rate jitter is less than 0.05%. Delay and width jitter is less than 0.1%.

1.9 MAIN PULSE OUTPUT

Positive and negative outputs are provided simultaneously. Outputs are dc coupled.

1.9.1 Peak Amplitudes (separately controlled for Positive and Negative Outputs).

Continuously variable from less than 10 mv to 10v into 50 ohms.

1.9.2 Rise and Fall Times 10 to 90% Points (simultaneous control of Positive and Negative Outputs).

With outputs terminated into 50 ohms, continuously variable from less than 6 nanosec to at least 0.5 millisec, covered in five decade related ranges by a common control plus separate fill-in controls for rise and fall times. Transition times slower than 20 nanosec are linear within ±5%. Maximum ratio of leading to trailing edge transition times, or vice versa, is typically 15:1. Ratios up to 100:1 are available on special order.

1.9.3 Pulse Baseline Offset

By means of front panel controls, the baseline offset may be independently adjusted from +2v to -10v on the positive output, and from -2v to +10v on the negative output. Baselines may be set at ground (Zero Volts) by panel toggle switches.

1.9.4 Waveform Aberrations (with properly connected 50 ohm load).

Overshoot, undershoot, ring, and top slope are less than 3% at amplitudes of 300 mv and higher.

1.9.5 Output Protection (with baseline at ground).

Output stages will not be damaged by any combination of panel control settings, short circuits of any duration, or back voltages up to 10v.

1.9.6 Output Mixing

Positive and/or negative outputs of multiple units may be directly mixed with each other or with other outputs (±10v max.) provided baseline offset is at zero volts. Mixed outputs add approx. algebraically to a maximum of 10v.

1.10 OPERATING TEMPERATURE

The unit is rated for operation with ambient temperatures from 0° to 50°C.

1.11 POWER REQUIRED

105v to 125v, 50-400 cycle ac, approx. 50 watts. 220v operation may be specified at no added cost.

1.12 PHYSICAL

Aluminum panel with etched red and black markings, beige cabinet with quick-release top and bottom covers, BNC signal connectors. 5 1/2" H x 17" W x 15 1/4" D, approx. 30 lbs. May be rack mounted (5 1/4" H x 19" W panel space) by specifying Model 110R, or by installing Type 1003 Rack Mounting Set.

1.13 ACCESSORIES FURNISHED

One operation and maintenance manual, 8 ft. line cord with NEMA 3-prong plug.

1.14 ** **ACCESSORIES AVAILABLE**

Type 2201 Mixer (for best waveform when mixing same polarity outputs of two units); Type 2003 Termination, 50 ohms, 25w; Type 1003 Rack Mounting Set, and extra instruction manuals.

SECTION II

OPERATING INSTRUCTIONS

2.1 DESCRIPTION OF CONTROLS AND CONNECTORS

2.1.1 Power Switch

Connects or disconnects ac input voltage to transformer primaries within instrument.

2.1.2 Pilot Lamp

Lights when power is ON..

2.1.3 Repetition Rate

The black outer knob selects Repetition Rate Range. There are seven ranges, each covering one decade of frequency. One position is provided for single pulse operation; one position for external triggering with positive going waveforms, and one position for triggering with negative going waveforms.

2.1.4 Repetition Rate Vernier

The inner red knob on the Repetition Rate Control provides continuous fill-in between 4 cps and 4 Mc. In the 40 Mc range, fill-in is provided by the 4-40 Mc Vernier (black knob). The two Verniers are automatically switched in and out by the Repetition Rate Control.

2.1.5 Single Cycle Button

This control provides one cycle of operation for each depression of the pushbutton. To operate, the Repetition Rate Control must be turned to the Single Cycle position.

2.1.6 Pulse Mode Switch

Single or Double Pulse Mode selects front panel toggle switch. In the Double Pulse Mode, two main pulses are provided at the output during each cycle (identical in width, amplitude, polarity, rise time, and fall time), one approximately coincident with the Sync Output and the second at a position determined by the Pulse Delay Controls.

2.1.7 External Trigger Input Jack

BNC connector accepts a pulse or sine wave to slave oscillator to outside signal with Repetition Rate Control in EXT. position.

2.1.7.1 Trigger Input Impedance Switch. This switch determines whether the input impedance of EXT. Trigger circuit is 50 ohms or 500 ohms. For fast rise time or high frequency input signals, use 50 ohm coax cable to bring the signal to the EXT. Trigger Input Jack, and place the switch at the 50 ohm position. For slow signal, place the switch at the 500 ohm position to minimize loading of the signal.

2.1.8 External Sensitivity

Adjusts the level on an external signal at which the oscillator triggers.

WARNING

Maximum dc level or transient amplitude which may be applied is ±25v with sensitivity control at maximum.

2.1.9 Negative Sync Output

The negative Sync Output is taken from this BNC jack. Because of the fast rise time of the Sync Output signal, a 50 ohm coax cable should be used to convey the signal. For reliable operation, the signal should be terminated into a 50 ohm load.

2.1.10 Gate Input

This BNC connector provides input for an external gating signal. When the dc level of signal is more positive than +3.5v, output pulses are disabled.

WARNING

Maximum is ±25v.

2.1.11 Pulse Delay Control

The black outer knob selects the delay range. There are seven ranges of which the last six are decades. The first range is quinary and provides coverage from 10 nanosec to 50 nanosec.

2.1.12 Pulse Delay Vernier

The red inner knob provides continuous fill-in between ranges of the Pulse Delay Control. With this control fully ccw the instrument is calibrated at the delay shown by the Pulse Delay Control.

2.1.13 Pulse Width Control

The black outer knob selects the width range. There are six ranges covering 10 nanosec to 5 millisec.

2.1.14 Pulse Width Vernier

The red inner knob provides continuous fill-in between ranges of the Pulse Width Control. With this control fully ccw the instrument is calibrated at the width shown by the Pulse Width Control.

2.1.15 Transition Time Range

This control determines the range of output pulse transition times. There are five ranges, each covering one decade.

2.1.16 Leading Edge Transition Time

This control provides continuous variation of leading edge transition time within the range set by the Transition Time Range Control.

2.1.17 Trailing Edge Transition Time

This control provides continuous variation of trailing edge trantition time within the range set by the Transition Time Range Control.

2.1.18 Positive Pulse Amplitude

The black outer knob sets the output voltage range. There are six ranges following a one, three, ten pattern, calibrated in volts when output is terminated with 50 ohms.

2.1.19 Positive Pulse Amplitude Vernier

The red inner knob provides continuous fill-in between positions of the Positive Pulse Amplitude Control. When this control is in the fully clockwise position the instrument is calibrated at the setting of the Positive Pulse Amplitude Control.

2.1.20 Positive Pulse Output

This BNC connector couples the variable parameter pulse to an external load.

2.1.21 Negative Pulse Amplitude

The black outer knob sets the output voltage range. There are six ranges following a one, three, ten pattern, calibrated in volts when output is terminated with 50 ohms.

2.1.22 Negative Pulse Amplitude Vernier

The red inner knob provides continuous fill-in between positions of the Negative Pulse Amplitude Control. When this control is in the full clockwise position, the instrument is calibrated at the setting of the Negative Pulse Amplitude Control.

2.1.23 Negative Pulse Output

This BNC connector couples the variable parameter pulse to an external load.

2.1.24 Positive Baseline Offset Switch

Front panel toggle switch which determines whether the baseline of the positive output pulse is at zero volts or at some value determined by the Baseline Offset Control. When the switch is in the zero volts position, the baseline is at zero volts independent of the setting of the Baseline Control.

2.1.25 Positive Baseline Offset Control

This is a 5 turn potentiometer which adjust the baseline of the positive pulse from +2 to -10 voltswhen the Baseline Offset Switch is in the VAR. position.

2.1.26 Negative Baseline Offset Switch

Same as Positive Baseline Offset Switch except that it controls the negative pulse baseline.

2.1.27 Negative Baseline Offset Control

Same as Positive Baseline Offset Control except that it controls the negative pulse baseline.

2.1.28 Fuse (Located on rear panel)

3 amp fast blow fuse protects against ac overload.

2.1.29 Power Input (Located on rear panel)

This 3 prong recessed male connector accepts a NEMA 3 wire line cord to supply ac power from the line.

2.2 PLACING IN OPERATION

2.2.1 Preliminary Settings

a. Set Repetition Rate Control to 400 kc, Vernier to maximum cw position.

b. Set Pulse Mode Switch to Single position.

c. Set Pulse Delay Control to 0.5μs, Vernier to maximum ccw position.

d. Set Pulse Width Control to 0.5μs, Vernier to maximum ccw position.

e. Set Transition Time Control to 5 nanosec, Verniers to the midscale positions.

f. Set Attenuators to 10v, Verniers to maximum cw position.

g. Load positive and negative with 15w, 50 ohm terminations.

h. Set Baseline Offset Switches to the zero volts positions.

i. Turn the Baseline Offset Controls to the maximum ccw positions.

j. Turn power ON, pilot lamp should light.

k. Sync oscilloscope from Negative Sync Output. Set scope sweep for 0.1μs/cm and vertical sensitivity to 5v/cm.

l. Monitor Model 110 outputs directly at the terminating resistors with high impedance probes.

m. Compare the positive output against that shown in Figure 2-1.

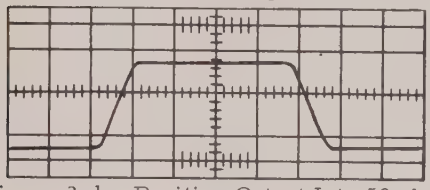
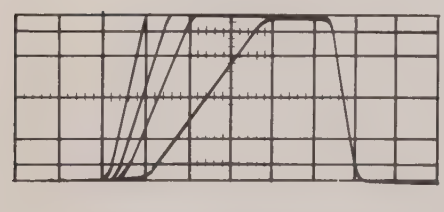


Figure 2-1. Positive Output Into 50 ohms As Seen On Tektronix 541A. Horizontal-0.1μs/cm. Vertical Sensitivity -5v/cm.

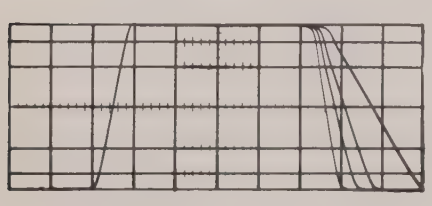
n. Set the Positive Baseline Offset Switch to the VAR. position. The baseline of the positive pulse should drop to -10 volts. Turn the Positive Baseline Offset Control in the cw direction, the baseline should go positive and should be at +2 volts when the control is at the maximum cw position. Waveslope should remain unaltered as control is varied.

o. Turn the Positive Amplitude Vernier in the ccw direction. The amplitude of the positive pulse should decrease without any noticeable effect in waveshape until the 3 volt amplitude level is reached.

p. Vary the Transition Time Verniers; the rise and the fall time should vary. The variations should be independent of each other. Refer to Figure 2-2 showing rise and fall time variations.



a. Multiple Exposure at Rise Time Variation at Constant Fall Time.



b. Multiple Exposure of Fall Time Variation at Constant Rise Time.

Figure 2-2. Multiple Exposure Showing Action Of Transition Time Verniers.

q. Return Transition Time Verniers to the midscale settings.

r. Compare the negative output against that shown in Figure 2-3.

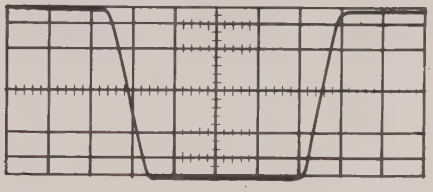


Figure 2-3. Negative Output Into 50 Ohms As Seen On Tektronix 541A. Horizontal-0.1μs/cm. Vertical 2.5v/cm

s. Set the Negative Baseline Offset Switch to the VAR position. The baseline of the negative pulse should drop to -2v. Turn the Negative Baseline Offset Control in the cw direction. The baseline of the negative pulse should increase in the position direction and should be at +10 volts when the control is maximum cw. Check for constant waveshape as the control is varied.

t. Turn the Negative Amplitude Vernier in the ccw direction; the amplitude of the negative pulse should decrease. There should not be any noticeable change in waveshape until the 3 volt amplitude is reached.

u. Vary the Transition Time Verniers; the rise and fall times should vary. Check for constancy of fall time as rise time is varied and vice versa; the resulting waveshapes should be the inverse of those shown in Figure 2-2.

v. Vary the Pulse Delay Vernier; the pulse width should vary linearly without any "skips".

w. Vary the Pulse Delay Vernier; the position of the leading edge should move smoothly as a function of the control movement.

x. Return all controls to the preliminary settings.

y. Set the Pulse Mode Switch to the Double Pulse position. The resulting waveshape should be as shown in Figure 2-4.

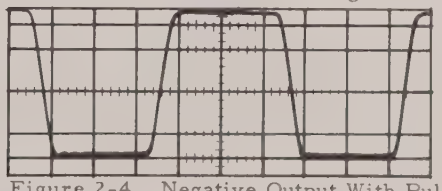


Figure 2-4. Negative Output With Pulse Mode Switch In Double Position Horizontal 0.5μs/cm. Vertical 3.3v/cm.

z. Vary the Pulse Delay Vernier. The position of the first pulse should remain constant. The delay between the first and second pulse should vary as the control is varied. Vary the Pulse Width Vernier. The widths of both pulses should increase as the control is varied. In like manner, check to see that the Transition Time Verniers and the Amplitude Controls vary both pulses simultaneously.

aa. Turn the Repetition Rate Control to the Single Cycle position. Depress the Single Cycle pushbutton. One and only one cycle of operation should occur for each depression of the pushbutton.

bb. Turn the Repetition Rate Control to EXT. position. Turn the Sensitivity Control to the MAX. position. Set the Input Impedance Switch to the 50 ohm position. Feed a -1.5 volt signal of 20 nanosec minimum pulse duration and 10 nanosec rise time to the Trigger Input by means of a 50 ohm coaxial cable. The unit should trigger reliably under these conditions. Repeat the same test using a +1.5 volt signal and the Rep. Rate Control in the EXT, + position,

cc. If the instrument does not meet any of the above conditions, repeat test and and check for correct control settings. In the event that the instrument still does not operate as indicated, notify the factory or an authorized sales representative.

2.3 OPERATING INSTRUCTIONS

2.3.1 External Triggering

When the Repetition Rate Control is in the EXT.- or the EXT.+ position, the Model 110 can be driven from an external source provided that the driving signal is greater than 1.5v in amplitude and 20 nanosec in width. The rise time of the external signal must be less than 20 nanosec; for slower rise time signals, the amplitude must be increased (up to a maximum of 3.5v for rise times of 1μsec or slower). In the EXT.-position the circuit will trigger on the negative going slope of the input waveform; in the EXT. + position, the circuit triggers on the positive going position.

When externally driving the Model 110, always set the sensitivity control to the full counter-clockwise position before application of the driving waveform. This will insure that no damage will be done to the Schmitt trigger should the driving waveform be greater than ±25v in amplitude. With the external signal applied to the external trigger input jack and the sensitivity control in the ccw position, adjust the sensitivity clockwise until stable triggering is obtained. Do not advance the sensitivity control any more than is necessary as the lowered input impedance and attendant overdrive may cause severe distortion of the input signal which can result in unstable multiple triggering of the Model 110.

WARNING

Always insure that the driving signal is less than 25v when the sensitivity control is in the maximum (clockwise) position to avoid damage to the Schmitt trigger circuit.

When the external driving signal is less than 0.1μs in rise time or greater than 1 Mc in frequency, it should be conveyed to Model 110 by means of a 50 ohm coaxial cable. The input impedance switch should then be set to the 50 ohm position to properly terminate the coaxial cable. For slower driving signals, the input impedance can be set to 500 ohms to minimize loading. When externally triggering the Model 110 above 5 Mc, the Input Sensitivity Control may have to be readjusted as the frequency of the driving signal is changed.

2.3.2 Duty Cycle Limitations

At duty cycles greater than 70%, the pulse delay and width one shot multivibrators may fail. There are no average current or power limitations imposed on the Model 110, however, under excessive duty cycle conditions instability and severe amplitude reductions occur. In order to minimize confusion and inaccurate data which will most certainly result from excessive duty cycle, it is recommended that the delay and width controls be set to their minimum position when frequency is being changed, and then reset to the desired settings upon completion of frequency shift. In this manner it is highly improbable that duty cycle rating will be exceeded while the frequency control is adjusted. Duty cycles of 100% can be obtained by the use of the Baseline Offset Controls. This technique is explained in paragraph 2.3.8.1.

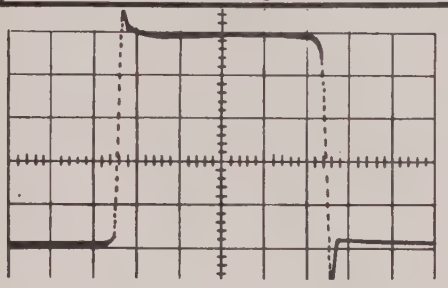
2.3.3 Transition Time Control

The Model 110 features an extremely versatile rise and decay time control. The leading and trailing edge transition times may be independently varied over a range of greater than 10:1. In addition, both edges are linear to within ±10% as measured from the best straight line between the 10% and 90% amplitude points. This feature virtually eliminates errors which usually creep in during setting up of rise and decay for a particular test, insuring repeatability of results and consistent data from test to test.

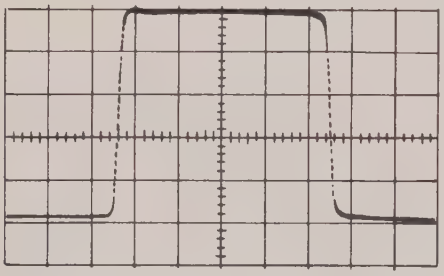
The transition time range control varies both the rise and decay times simultaneously in decade steps from less than 6 ns to greater than 0.5 ms. The transition time leading edge and trailing edge controls are independent and provide continuous fill-in within a transition time range. With this form of control it is possible to produce waveforms with leading edge transition time differing from trailing edge transition time by a ratio of greater than 10:1, enabling the Model 110 to generate useful functions such as ramps, sawteeth, triangles and trapazoids, where required.

2.3.4 Output Characteristics

2.3.4.1 Amplitude Control: The outputs of the current drivers are coupled to their respective BNC connectors by the use of constant impedance attenuators. Each output has an independent attenuator providing over 60db attenuation in 10db steps, plus an uncalibrated fill-in control capable of over 20db. However, for minimum distortion of output pulses, the fill-in control should not be adjusted to give over 10db (1/3 amplitude). See Figure 2-5. The attenuators are calibrated in volts rather than db to provide faster interpretation of dial readings.



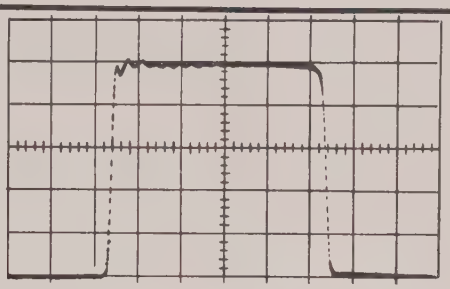
a. Positive Output Pulse Attenuated to 1v (20db) Using Fill-in Control Only.



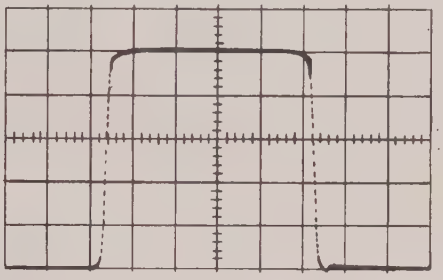
b. Positive Output Pulse Attenuated to 1v (20 db) Using Step Attenuation only

Figure 2-5. Photographed from Hewlett-Packard Model 185 Sampling Oscilloscope, 50 nanoseconds/cm, 0.2v/cm.

2.3.4.2 Loading of Idle Output: Because of the fast rise times involved, the current amplifiers have a tendency to radiate when unloaded. When only one output is being used at rise times faster than 25 ns, it will be necessary to load the idle output with 50 ohms to prevent ringing on the output pulse due to radiation. The most convenient method of loading the idle output is to set the attenuator to the 0.3v position as the attenuator has a characteristic impedance of 50 ohms; at rise time settings of less than 15 ns, an unloaded idle output can cause distortions of greater than 2% on the output being used. See Figure 2-6. Therefore, in order to meet equipment specification with regard to pulse distortion it is mandatory that the user adheres to the instructions given above.



a. Positive Output with Negative Output Open Circuit. Note Ring On Leading Corner.



b. Positive Output Pulse Attenuation. Set at 0.3v. Note Relative Lack of Ring.

Figure 2-6. Photographed from Hewlett-Packard, Model 185B Sampling Oscilloscope 50 nanoseconds/cm, 2v/cm.

2.3.5 Loading Considerations

One of the major advantages of the Model 110 over competitive pulse generators is its clean waveforms, even at fast rise times. In order to preserve this degree of pulse fidelity, it is imperative that due consideration is given to loading. The generation of a clean waveform with rise times which are variable between the limits from 6 ns to over 0.5 ms requires state of the art circuit design and packaging technique. As such, it is necessary to restrict the type of loading which can be imposed upon the output stages. Because of the wide usage of 50 ohm cables and accessories in industry, the Model 110 was designed for operation with a 50 ohm load.

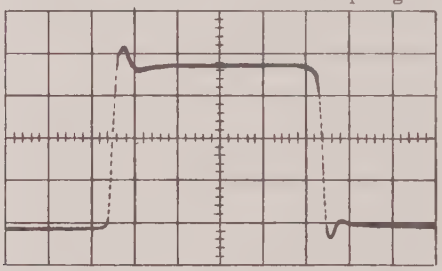
The output section of the Model 110 consists of a positive and a negative current amplifier each supplying 200 ma. The operating point of each amplifier is biased near saturation when supplying 200 ma into a 50 ohm load. The load impedance must not vary more than ±5% from 50 ohms if the specified overshoot and undershoot specifications are to be met. Load impedances over 50 ohms causes saturation of current amplifiers and hence, introduces storage time effects; on the other hand, load impedances less than 50 ohms increase the collector voltage of the transistors in the current amplifiers which causes

overshoot and ringing (See Figure 2-7). If the outputs are open circuited, the current amplifiers will be in deep saturation and the resultant waveform may be indistinguishable as pulses.

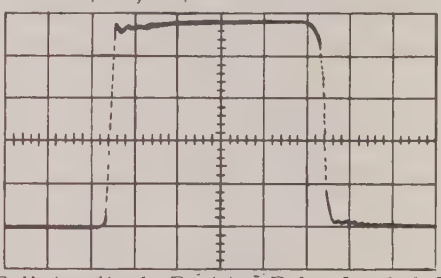
2.3.6 Cabling Considerations

In most cases the Model 110 will be used to drive loads which are physically separated from it by several feet. In this case, it will be necessary to convey the signal by means of a 50 ohm transmission line. Preservation of low distortion waveforms is largely contingent upon the method of cabling and in proper termination of the transmission line. Clean waveforms are maintained by connecting the generator to its load with 50 ohm coaxial cable, and terminating the cable AT THE LOAD into 50 ohms. This is also true of the Sync connection to the scope.

Figure 2-7. Photographed from Hewlett-Packard, Model 185B Sampling Oscilloscope 50 nanoseconds/cm, 2v/cm.

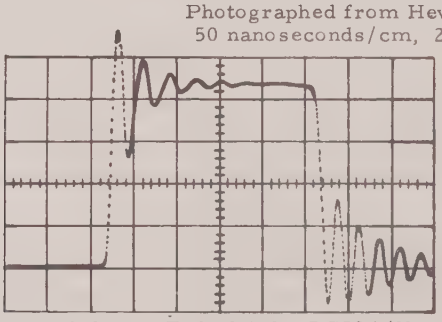


a. Full Amplitude Positive Pulse Loaded into 40 ohms. Note Overshoot and Undershoot.

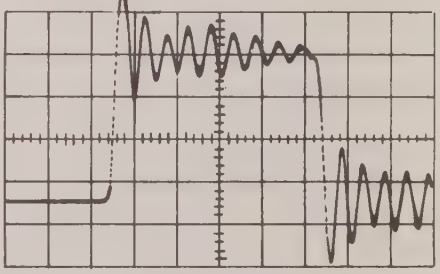


b. Full Amplitude Positive Pulse Loaded Into 60 ohms. Note Ring and Top Slope.

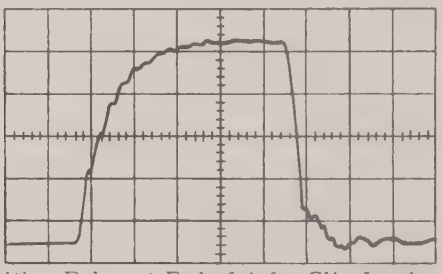
Figure 2-8.
Photographed from Hewlett-Packard, Model 185 Oscilloscope 50 nanoseconds/cm, 2v/cm. (e) is 0.5 microsecond/cm.



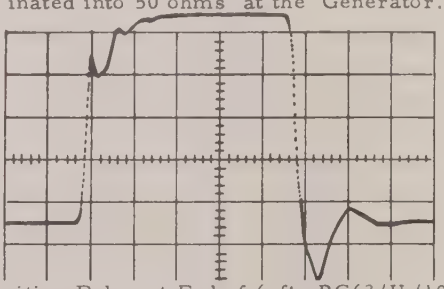
a. Positive Pulse at End of 4-ft. RG58A/U Cable Terminated in 50 ohms at the Generator



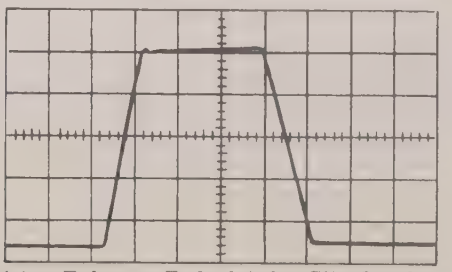
b. Positive Pulse at End of 4-ft. Clip Leads. Terminated into 50 ohms at the Generator.



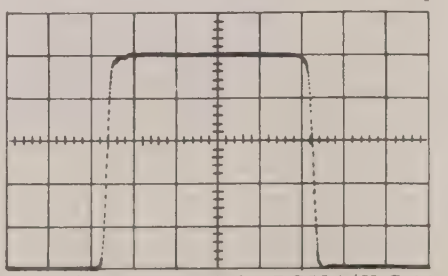
c. Positive Pulse at End of 4-ft. Clip Leads. Terminated into 50 ohms at Scope.



d. Positive Pulse at End of 6-ft. RG63/U (100) Cable Terminated into 50 ohms at Scope.



e. Positive Pulse at End of 4-ft. Clip Leads. 50 ohm Load at Scope. Rise time Set for Approx. 0.5μs.



f. Positive Pulse through 4-ft. RG58A/U Cable Terminated in 50 ohms at Scope (Good Technique).

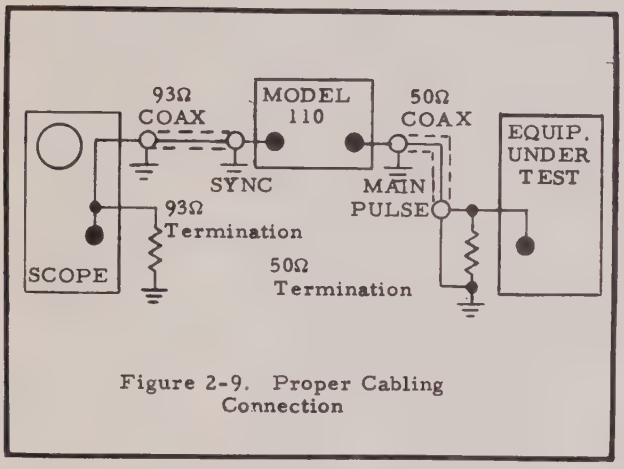


Figure 2-9. Proper Cabling Connection

2.3.7 Non-Linear Loads

In many cases, the unit will be used to drive non-linear loads such as transistors and diodes. This type of loading generally exhibits high impedance in one direction and low impedance in the other direction. Care must be taken to insure uniform loading on the unit in both directions to obtain clean waveforms. Figure 2-10 illustrates some of the methods whereby the unit could be terminated when driving into the base of a transistor. The same techniques apply when driving diodes since the base of a transistor resembles a diode.

The external connections shown in Figures a, b, & c, are suggested for driving into transistor stages. In these examples the "speed up" capacitor will slow down the rise and fall times of the main output pulse. Ringing may occur if the transistor load improperly terminates the generator. It is advisable not to adjust the rise and fall time of the output any faster than is required, since load mismatch is more pronounced at this higher rise/fall frequency. These examples illustrate methods of referencing the output pulse so that the transistor will be back biased in the quiescent state. Also refer to paragraph 2.3.8.

2.3.7.1 Decoupling Output for Non-Linear Loads: When minimal pulse distortion is required and the load is non-linear, it might be necessary to decouple the Model 110 from the load by means of an emitter follower. The transistor used for the emitter follower must have the following requirements:

a. It must have the frequency response necessary to give the rise and fall times required.

b. Its input capacitance must be low in order to minimize pulse distortion.

c. It must have sufficient gain to supply the current required by the load.

d. It must have sufficient power and voltage required by the load.

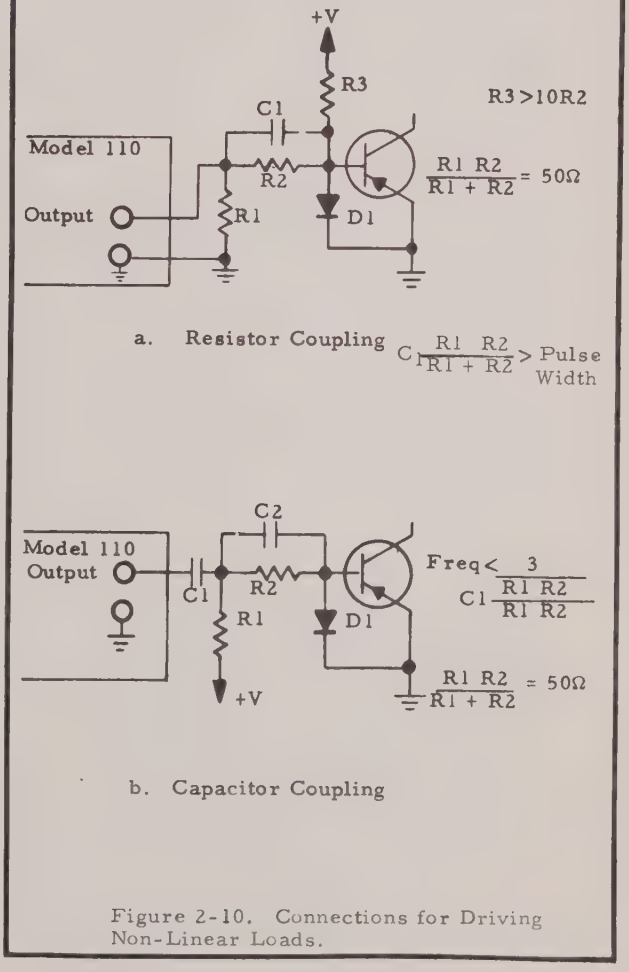


Figure 2-10. Connections for Driving Non-Linear Loads.

The positive output should be decoupled by means of NPN transistors and the negative output should be decoupled by means of PNP transistors. The receiving end of the cable should be terminated directly into a 50 ohm resistor and the input of the emitter follower should be connected to the cable by means of a 22 ohm resistor. See Figure 2-11. The resistor is used as a parasitic suppressor and is absolutely necessary in order to minimize pulse distortion at fast rise and fall times. Of course, the operating voltages and the necessary resistors of the emitter follower are determined by the magnitudes of the voltage and current required by the load.

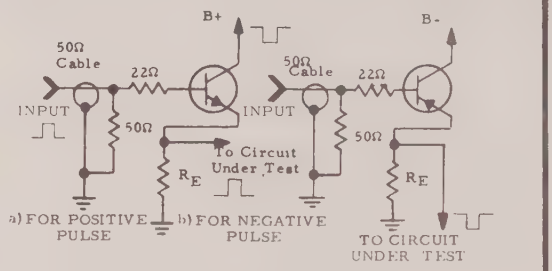
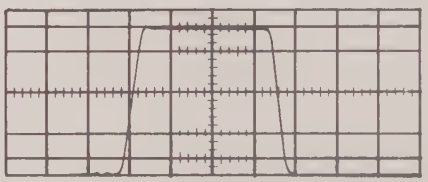
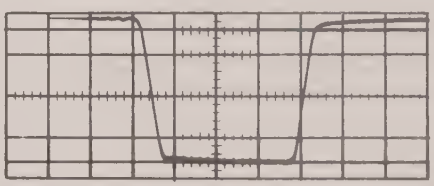


Figure 2-11. Decoupling Output for Non-Linear Loads.



a. Photo of Positive Output Used To Simulate "1" side of Flip Flop.



b. Photo of Negative Output Used To Simulate "0" Side of Flip Flop.

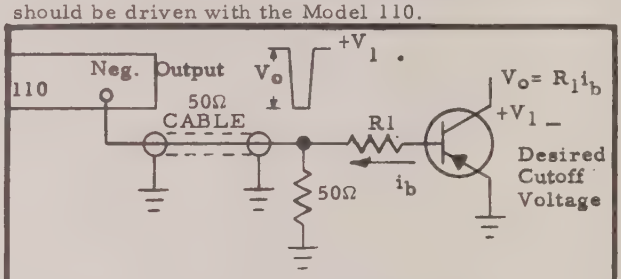
Figure 2-12. Photos Showing 110 Used To Simulate Both Outputs of Flip Flop.

2.3.8 Baseline Offset Applications

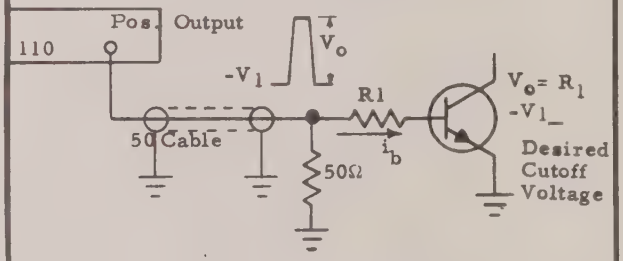
The Baseline Offset feature of the Model 110 allows the user to simulate almost all of the logical levels in use today. By means of this feature, the user is able to derive signals with the correct reference levels to hold transistors and vacuum tubes in the cut off state without resorting to external biasing techniques. By correct adjustment of the Baseline Offset Controls, the Model 110 can be used to simulate the outputs of both sides of multivibrator type circuits such as a flip flop. Figure 2-12 shows the positive and the negative outputs with their baselines adjusted to simulate the output from both sides of a flip flop.

In this case, the Positive and Negative Amplitude Controls were set to provide the desired voltage swing. If the flip flop was swinging from 0v to +6v, then the amplitude controls would be set for an output of 6 volts. The baseline of the positive output is then set at 0v while the baseline of the negative output is set at +6 volts.

By proper use of the Baseline Offset Controls, the Model 110 can be used to drive the bases of transistors and grids of most vacuum tubes without the use of of biasing networks and voltages. Figure 2-13 illustrates the manner in which transistors and tubes should be driven with the Model 110.



a. Proper Method of Driving PNP So That Transistor Is Normally in the Off State.



b. Proper Method of Driving NPN So That Transistor Is Normally in the Off State. This Same Technique is Used for Vacuum Tubes.

CAUTION

$+V_1$ and $-V_1$ should not exceed the inverse base to emitter breakdown voltage to prevent damaging the transistors under test.

Figure 2-13. Methods of Driving Transistors and Vacuum Tubes and Holding Them Cut-off in the Quiescent State Without Use of Biasing Networks and Voltages.

The magnitudes of the baselines are unaffected by the attenuator settings. This means that waveforms can be generated in which the baseline can be 10 volts while the pulse amplitude is in the millivolt range. Coupled with the Transition Time Controls, this feature allows the user to simulate DC voltages in which there are minute perturbations (the pulse output itself) as a result of loading or poor regulation. In fact, the Model 110 can be used as a DC power supply (capable of 200 ma), provided that a filter capacitor is not used on its output. This then can be used to drive circuits which are susceptible to noise and ripple. The amplitude and shape of the noise can be selected by the attenuator and Transition Time Controls. Figure 2-14 illustrates a typical application in which a +10 volt output has small voltage excursions superimposed to simulate ripple.

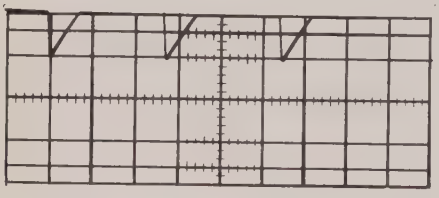


Figure 2-14. Photo of Negative Output Set For +10 Volt Baseline and 100 mv Output

Another interesting application of the baseline offset feature of the Model 110 is in the testing of voltage sensitive circuits such as peak voltage detectors. The amplitude control is initially set for zero output and the baseline is adjusted for a value slightly below the circuit threshold point. The amplitude control is then advanced until the circuit operates. In this manner, the incremental sensitivity of the circuit can be found. In addition, because the occurence of the event is known in time, the operation of the circuit during switching can be observed. There are many other applications of the baseline offset feature. These will be apparent to the user as familiarity with the instrument is obtained.

2.3.8.1 Generating High Duty Cycle Pulses

By use of the Baseline Offset Controls and complementary pulses, the Model 110 can be made to generate pulses with duty cycles of up to 100%. Assume that a positive pulse of 6 volts in amplitude with baseline at 0v and a duty cycle of 95% is required. This is easily generated by using the negative output as follows:

a. Adjust width of the negative output for 5% duty cycle.

b. Adjust amplitude of negative pulse for 6 volts.

c. Adjust baseline of negative pulse for +6 volts.

d. The result is a train of positive pulses going from ground to +6 volts with a duty cycle of 95%.

This technique of generating high duty cycle pulses amounts to using the off time of the opposite polarity output as the pulse itself. The result of the above procedure is shown in Figure 2-15. The general procedure to follow in setting the Model 110 for high cycle is:

a. Adjust opposite polarity duty cycle of (100%-duty cycle desired).

b. Adjust opposite polarity amplitude for desired voltage swing.

c. Adjust opposite polarity baseline for value of 0v± voltage swing.

Because of the clean baselines inherent in the Model 110, the resulting waveform is indistinguishable from those generated in the conventional manner.

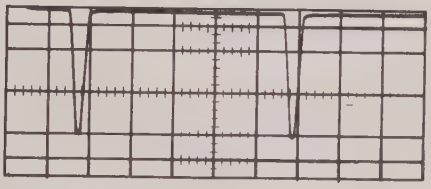


Figure 2-15. Photo Showing 95% Duty Cycle Pulses By Means of Baseline Offset and Complementary Output. (Positive Output).

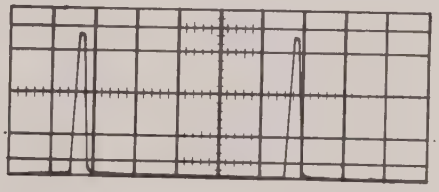


Figure 2-16. Photo Showing 98% Duty Cycle Negative Pulse.

2.3.9 Mixing of Several Outputs

The outputs on the Model 110 may be mixed with other outputs if the common load is 50 ohms and if the amplitudes involved are less than 8v. If the outputs of two Model 110's are mixed, the resulting amplitudes will be one-half their unmixed value unless the attenuators of both units are in the 10v position.

The reason for this is that the output impedance of the attenuator is 50 ohms and, therefore, the resulting load in two Model 110's in parallel working into a common 50 ohm load is 25 ohms.

Mixing the outputs in general will degrade the rise time and cause pulse distortion. This condition is usually caused by the output impedance of the units in parallel having reactive components. The transition time and the pulse distortion of the Model 110 are given only for a resistive load. Any reactive loading on the output terminal will increase the pulse distortion and the rise and fall times. Best results will be obtained when the DATAPULSE 2301 Mixing Unit network is used to tie the output together.

The use of this mixing network will cause the resulting amplitude to be one half of its unmixed value. However, pulse distortions will be minimized.

2.4 SPECIAL APPLICATIONS

2.4.1 Multiple Pulse or Pulse Train Operation Using Several Model 110's.

Magnetic device testing, beacon development, and digital or other pulse code simulation often require multiple pulse or pulse train signals. Multiple Datapulse 110 Pulse Generators, when properly connected, will satisfy a broad range of requirements of this type.

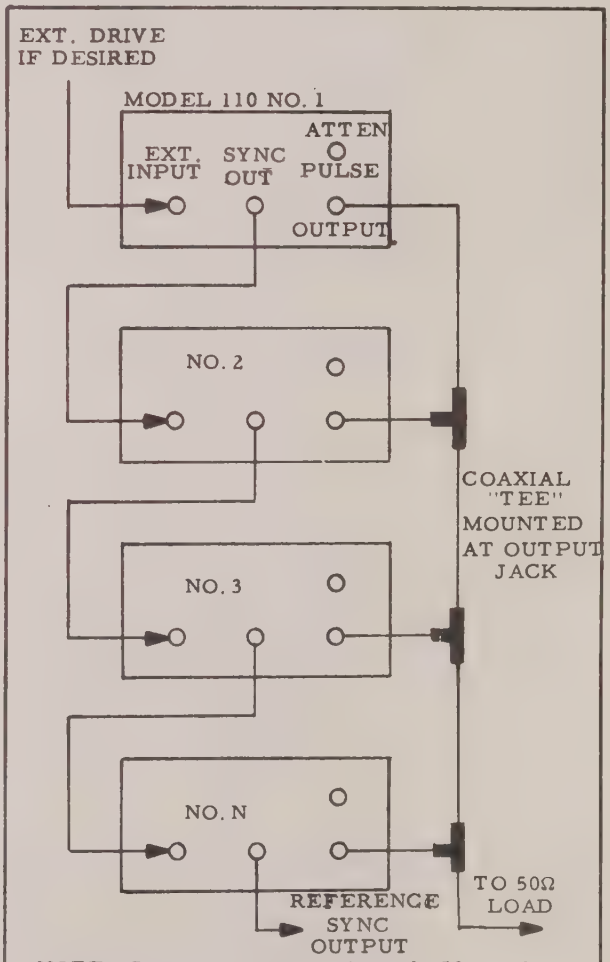
Mixing the outputs of several 110's, instead of purchasing a special purpose multi-pulse generator, offers many advantages. First, pulse parameters may be controlled individually; second, all pulses are selectable in polarity -- a feature not always available on multi-pulse generators; third, such an arrangement is more versatile since the individual units may be broken down for use on other projects; and fourth, the combination of simple, proven, easily operated 110's is more dependable than complex special gear.

The 110's may be driven in parallel from an external source, if sync with outside phenomena is desired, or driven in tandem (see Figure 2-17) using the sync output of one generator to externally drive the next. The first generator may be driven from an external source in the tandem arrangement also. Because of the fast rise character of the pulses and narrow widths available, pulse repetition rates approaching 100 mc may be synthesized.

The termination of interconnecting cables has an important effect on output waveform in this arrangement. Improper termination causes reflections which deteriorate wave shape and increase the rise time. However, good waveform fidelity can be obtained, by inserting some measure of attenuation (the amount varying with the number of generators) at the generator end with the internal attenuator. The 50 ohm output impedance of the attenuator tends to terminate the interconnecting cables. The greatly decreased waveform distortion more than offsets the slight loss of amplitude sustained. (See para. 2.3.8).

2.4.2 Positive Sync Output

Some applications require positive polarity sync pulses which are not normally available in the Model 110. DATAPULSE Model 2101 Trigger Pulse Inverting Transformer, available as an accessory, was designed to permit inversions of the negative sync pulse output.



NOTE: Sync occurs approximately 50 ns after external trigger. Reference sync will occur N x 50 ns after external trigger if N equals the number of generators.

Figure 2-17. Wiring for Multiple Pulse Output.

THEORY OF OPERATION

3.1 BLOCK DIAGRAM DESCRIPTION

A clock pulse, W1, with a repetition rate which is variable from 4 cps to 40 mc is generated by the internal oscillator. Either this signal or an external trigger input is applied to the Schmitt trigger circuit to provide a standardized trigger, W2. W2 is delayed 85 nanosec and becomes the negative sync pulse output which is used as the "Zero" time reference for the pulse delay circuit. W2 is also applied to the Gating Amplifier, which in the absence of an external gating signal, generates the system clock, W3. The clock drives the Delay Univibrator to produce a delay gate, W4. The lagging edge of W4 is differentiated by the Pick off Amplifier which provides the delayed trigger W5 for triggering the Width Univibrator. When the Pulse Mode Switch is in the double pulse position, the system clock W3 is also brought to the Mixing Amplifier together with W6 to trigger the Width Univibrator. In this model of operation, the Width Univibrator is triggered twice for every cycle. The width gate W8 produced by the Width Univibrator is applied to the rise and fall time circuit by the buffer amplifier.

The rise and fall time circuit shapes the leading and trailing edges of W8 to the desired values. The output of this circuit, W9, is fed to the Inverter Amplifier and to the Negative Output Amplifier. The Inverter Amplifier output, W10, drives the Positive Output Amplifier. The output W11 is coupled to the output BNC connector through a 50 ohm attenuator. The output of the Positive Baseline Offset is tied to the BNC connector and it causes the reference level of the Positive Output to vary from 0v as determined by a front panel control setting. The Negative Output Amplifier is driven directly from the Rise and Fall circuit. The output of the Negative Output Amplifier is brought to the BNC connector through a 50 ohm attenuator. The reference level of the Negative Output is controled by the Negative Baseline Offset circuit. The logic of the Model 110 and its timing waveforms are shown in Figure 3-1 and in Figure 3-2.

3.2 CIRCUIT DESCRIPTION

3.2.1 Internal Oscillator

The internal oscillator is an emitter coupled circuit which has the advantages of self-starting, stability, and high frequency operation. The basic circuit is shown in Figure 3-3. The actual oscillator is composed of Q2 and Q5. The function of Q1 is to provide the base voltage ($-V_2$) for Q2 and the clamp voltage ($-V_3$) for CR2. Q6 serves to decouple the load from the output.

Assume that Q2 has just turned on. The negative signal at the collector of Q2 is fed back to the emitter of Q2 through the emitter follower Q5 and the timing capacitor CT. This feedback is positive and it tends to keep Q2 in the ON state. During this phase, the emitter current of Q2 flows through CT and Q5 to -5 volts. This current charges capacitor CT. The charge on CT increases which causes the current through it to decrease. Eventually the charge accumulated in CT is sufficient to cause Q2 to be cut off. The collector of Q2 then rises back to ground. CT then discharges through R14 and R15. When CT discharges to value such that the emitter voltage of Q2 is more negative than its base voltage, Q2 turns on and the cycle is repeated again.

The duration of the ON period is determined by the value of R10 and CT. The duration of the OFF period is determined by the value of CT, RT, and R14. The repetition rate is the reciprocal of the sum of the two periods. The repetition rate maybe altered either by changing the value of RT or CT. In the Model 110, RT is the Vernier and CT is the Range.

3.2.2 Schmitt Trigger

The Schmitt Trigger is used to standardize waveforms either from the internal oscillator or from the external triggering source. Because of regeneration during switching, the output of the Schmitt Trigger has fast rise and fall times which are relatively independent of the input waveshapes. The simplified circuit is shown in Figure 3-4.

In the quiescent state, Q7 is ON and Q8 is OFF. A negative signal of 1.5 volts at either input A or input B will cause Q7 to cut off. The positive going signal at the collector of Q7 is coupled to the base of Q8 and turns it on. This positive signal is fed back to the emitter of Q7 and turns it off harder. The output of Q8 is a negative going signal of 3v with a rise time of less than 10 nanosec.

3.2.3 One Shot Multivibrator

The One Shot Multivibrator is used for delaying and providing the duration of the main output pulses. The circuit used in the Model 110 is an emitter coupled univibrator and the simplified circuitry is shown in Figure 3-5. Both the delay and width univibrators are similar and the description that follows apply to both.

Quiescently, Q26 is ON and Q27 is OFF. This condition is caused by the base of Q26 being positive by the forward voltage drop of CR121 and the base of Q27 being negative by the forward voltage drop of CR124. The collector voltage of Q26 is clamped to $+V_1$ by CR124 and this keeps Q26 out of saturation. Q28 is an emitter follower which provides feedback to Q27. The output signal is taken from the emitter follower, Q29.

Operation of the circuit is initiated by a negative pulse at the input of Q26. This cuts off Q26 and causes its collector voltage to rise to +5v. This positive pulse is fed back to the emitter of Q26 via Q28, CT, and Q27 and keeps Q26 in the OFF state. CT is discharged by RT to -25v and causes the feedback voltage to diminish in amplitude. When the feedback voltage diminishes to a value less than that required to keep Q26 in the off state, Q26 turns on again. This terminates the output pulse and the circuit returns back to its quiescent state.

The discharge of CT occurs in a linear manner because the magnitude of the feedback signal is small compared to -25 volts. Hence, the feedback signal crosses the switching threshold in a linear manner and this results in an output pulse having very low jitter. The duration of the output pulse is a function of both RT and CT. In the Model 110, CT is used as the Range Control and RT is used as the Vernier.

3.2.4 Pick Off Amplifier

The purpose of the Pick Off Amplifier is to differentiate the output of the Delay Univibrator. The trailing edge is inverted and becomes the input for the Mixing Amplifier. The simplified circuit is shown in Figure 3-6.

Q20 is an emitter follower which buffers the output of the Delay Univibrator. The output of Q20 is differentiated by the transmission line, DL80. The negative lagging edge is applied to the base of Q21 through CR85. Q21 is normally on because its base is more positive than its emitter. The negative pulse turns off Q21 and its collector goes positive. The output of Q21 is then applied to the Mixing Amplifier.

3.2.5 Gating Amplifier

The Gating Amplifier is used to generate the system clock and to interrupt it upon the application of an external gating signal. The amplifier is composed of Q14, Q15, and Q16 as shown in Figure 3-8. Q14 and Q15 form a differential amplifier and Q16 is an inverter. In the quiescent state, Q14 is ON and Q15 is OFF because the base of Q14 is more positive than the base of Q15. The output of the Schmitt trigger drives the base of Q14 which in the absence of an external gating signal, turns Q14 off. The positive pulse at the collector of Q14 is inverted by Q16. The system clock is taken from the collector of Q16.

To inhibit the clock output, a positive voltage of more than 3.5 volts must be applied to the base of Q15. This turns on Q15 and turns off Q14. By keeping Q14 in the OFF state, no output will result when negative pulses are applied to its base. Diodes CR63, CR64, CR65, and CR66 are used to clamp the base of Q15 both positively and negatively to prevent damaging Q15 due to excessive voltages at the gate input.

3.2.6 Mixing Amplifier

The purpose of the Mixing Amplifier is to generate the trigger pulse for the Width One Shot Multivibrator. The basic circuit is shown in Figure 3-7. Q23 and Q24 is an "OR" gate which provides power gain from the input to the output. Q22 is an inverter which provides an input to Q23 when the Pulse Mode Switch is in the double pulse position. When the Pulse Mode Switch is in the Single pulse position, CR113 clamps the collector of Q22 from going above ground.

Q25 is an inverter which accepts the output of the "OR" gate and drives the Width one shot. In the double pulse mode, Q25 generates two pulses for each cycle of operation; one at clock time and one at delay time. In the single pulse mode, the pulse at clock time is inhibited and only the pulse at delay time is generated.

3.2.7 Input Amplifier

The input amplifier is used to generate the driving signals for the Schmitt Trigger. The circuit is composed of Q9, Q10, and Q30 as shown in drawing 40000-101. R32 is a sensitivity control and is used to reject noise on the external input. S31 is used to control the input impedance and should be in the 50 ohm position when the external signal is brought to the input by means of 50 ohm coaxial cables. CR31 prevents the base of Q9 from being damaged due to excessive negative voltage swings.

The input is fed to the base of the emitter follower, Q9. The output of Q9 is AC coupled to a differential amplifier composed of Q10 and Q30. In the +EXT position, CR35 clamps any negative signal to ground. The positive signal is applied to the base of Q30 by CR36 and turns Q30 on. The negative signal appearing at the collector of Q30 is coupled to the Schmitt Trigger through CR7. In the -EXT position, CR34 clamps any positive excursions to ground and the negative signal is applied to the base of Q10 through CR32. This turns Q10 off and Q30 on and also results in a negative signal at the collector of Q30. The reason for having CR34 and CR35 is to prevent double triggering when the input signal is a sine-wave.

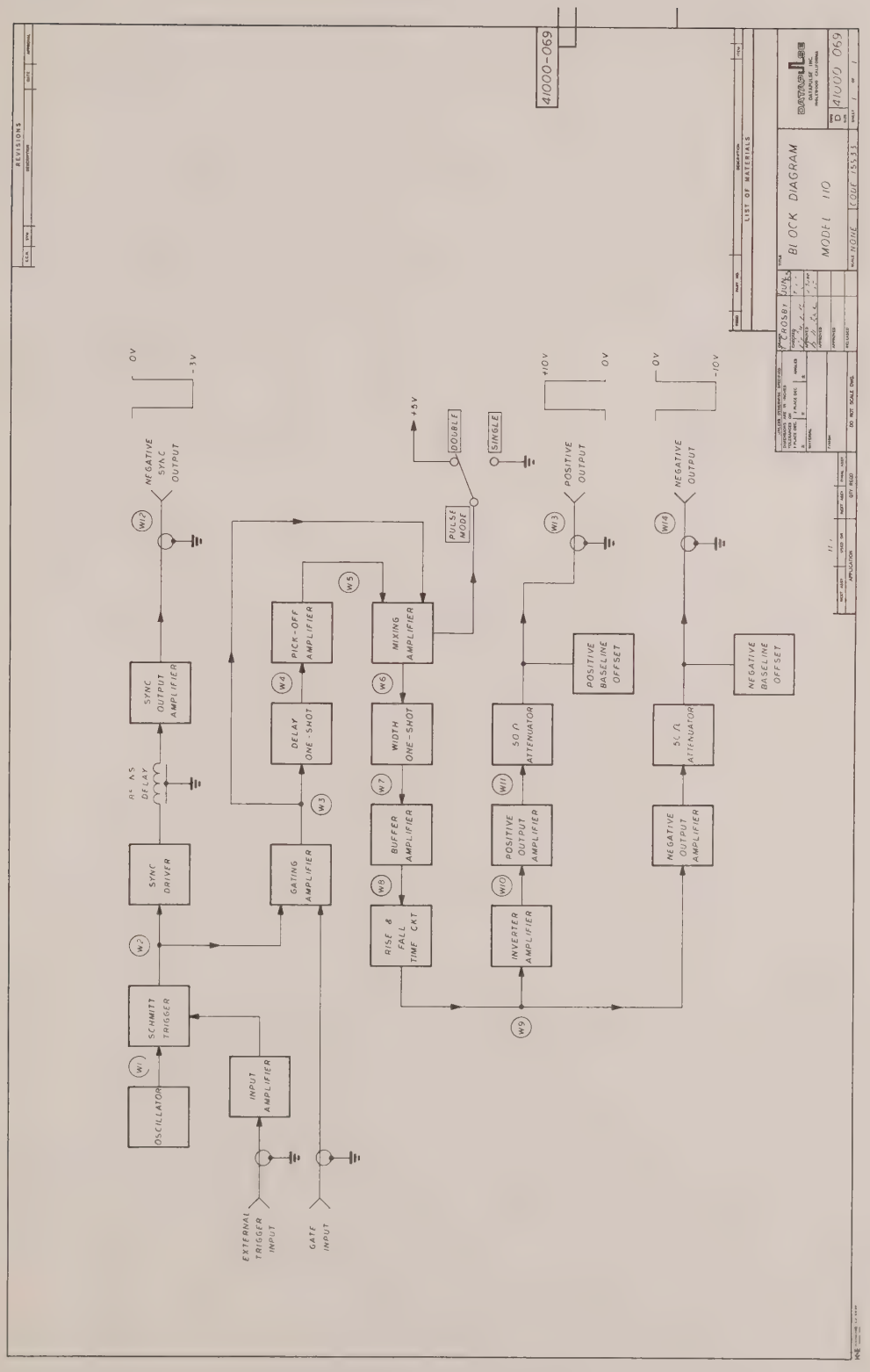
3.2.8 Power Supply

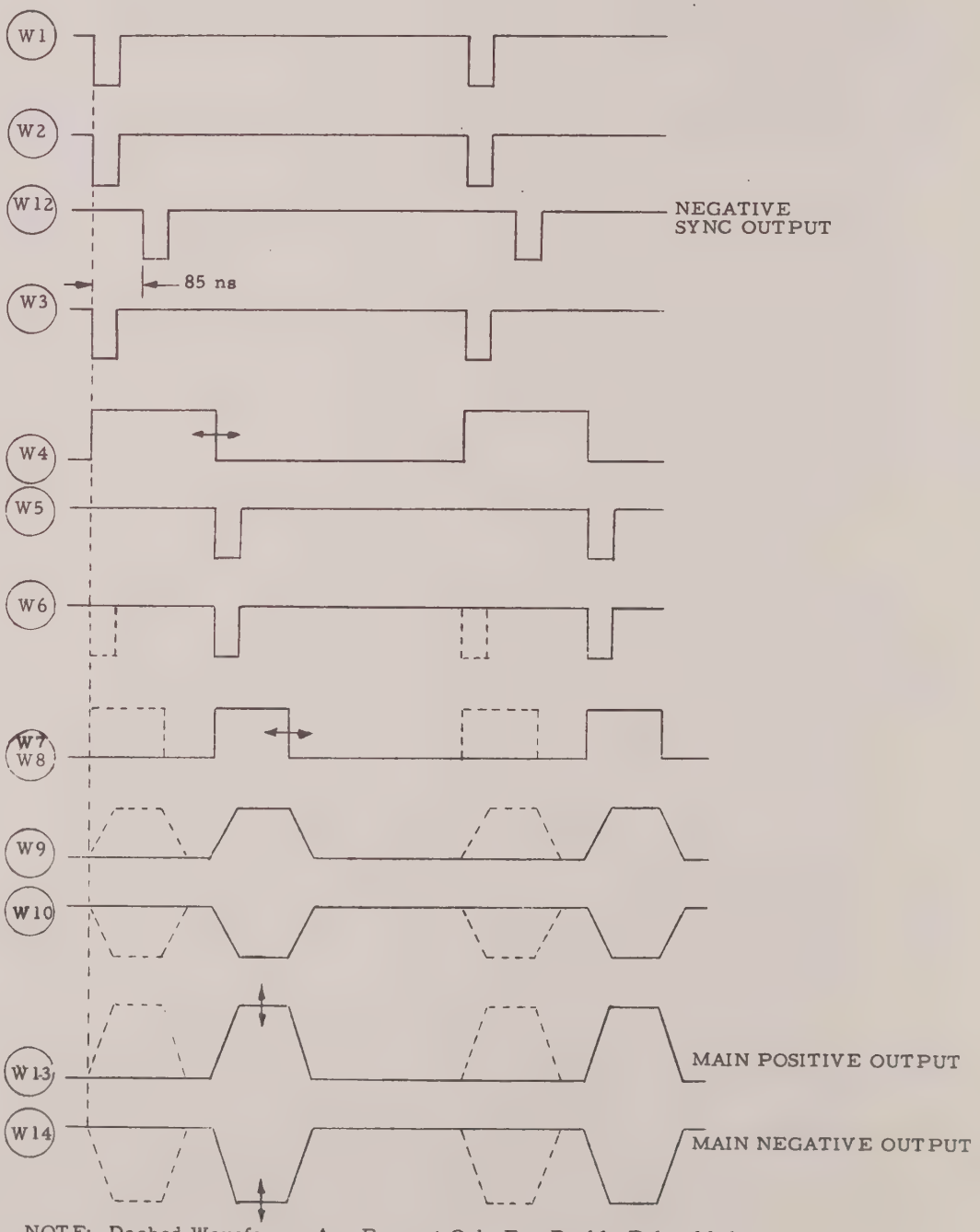
The power supply consists of two positive regulators and two negative regulators as shown in drawing 40000-133. The AC line input is stepped down to 29 VRMS to each secondary of T501. The secondary voltages are rectified by two bridge rectifiers, CR510, to CR513 for the positive voltage and CR531 to CR534 for the negative voltage. The output of the positive bridge rectifier is filtered by R510 and C510. The filtered output is regulated to +25 volts by a series type regulator composed of Q501, Q502, and Q503. Q501 is a reference amplifier which compares the output voltage against the output of the reference Zener diode CR514. The error signal is fed to the base of Q503 by means of emitter follower Q502. The polarity of this signal is such that it always opposes the change in the output voltage. The value of the output voltage is determined by the setting of R517. +25 volts is divided down by R519, R520, and R521 to generate +5 volts. Q505 and Q506 are used to supply +5 volts to the load. Both the +25 volt and the +5 volt regulators are protected against short circuit loads.

The output of the negative bridge rectifier is filtered by R551 and C531. The filtered output is regulated at -24 volts by a series regulator composed of Q508, Q509, and Q510. The operation of this regulator is the same as in the +25v regulator. -5 volts is generated by R540, R541, and R542. Q511 and Q512 supplies -5 volts to the load. As with the +25 and +5 volt regulators, the negative regulators are also protected against short circuit conditions.

3.2.9 Rise and Fall Circuit

The rise and fall time circuit generates the


41000-069
BLOCK DIAGRAM
MODEL 110
41000 069
OSCILLATOR
SCHMITT TRIGGER
INPUT AMPLIFIER
EXTERNAL TRIGGER INPUT
GATE INPUT
SYNC DRIVER
GATING AMPLIFIER
SYNC OUTPUT AMPLIFIER
NEGATIVE SYNC OUTPUT
0.1 µS DELAY
DELAY ONE-SHOT
PICK-OFF AMPLIFIER
RISE & FALL TIME CKT
BUFFER AMPLIFIER
WIDTH ONE-SHOT
MIXING AMPLIFIER
PULSE/WIDE
DOUBLE
SINGLE
+5V
0V
-3V
INVERTER AMPLIFIER
POSITIVE OUTPUT AMPLIFIER
50Ω ATTENUATOR
POSITIVE BASELINE OFFSET
POSITIVE OUTPUT
+10V
0V
NEGATIVE OUTPUT AMPLIFIER
50Ω ATTENUATOR
NEGATIVE BASELINE OFFSET
NEGATIVE OUTPUT
0V
-10V



NOTE: Dashed Waveforms Are Present Only For Double Pulse Mode.

Figure 3-2. Timing Diagram

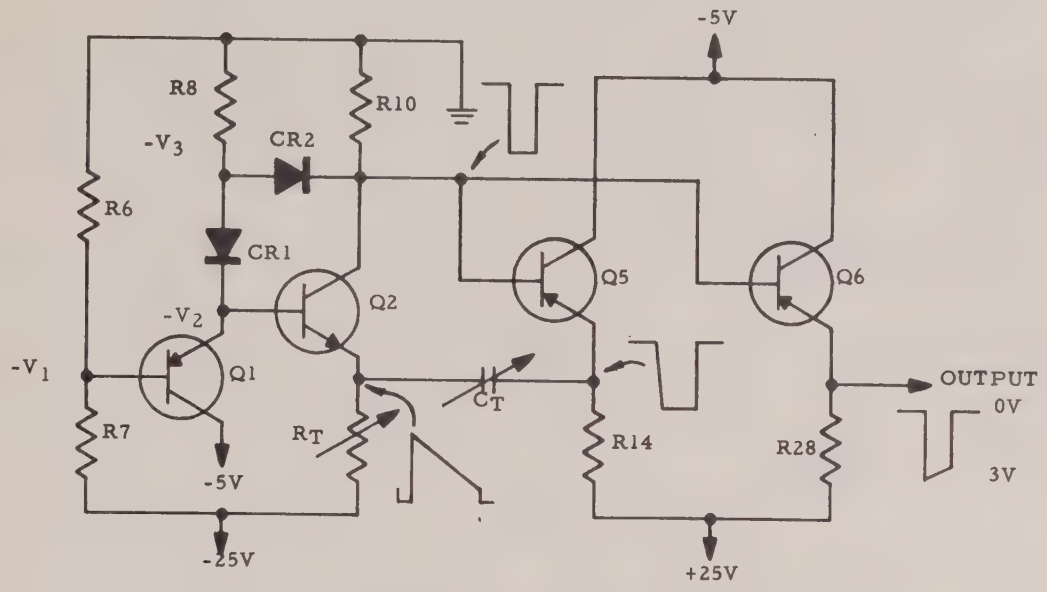


Figure 3-3. Simplified Internal Oscillator Circuits.

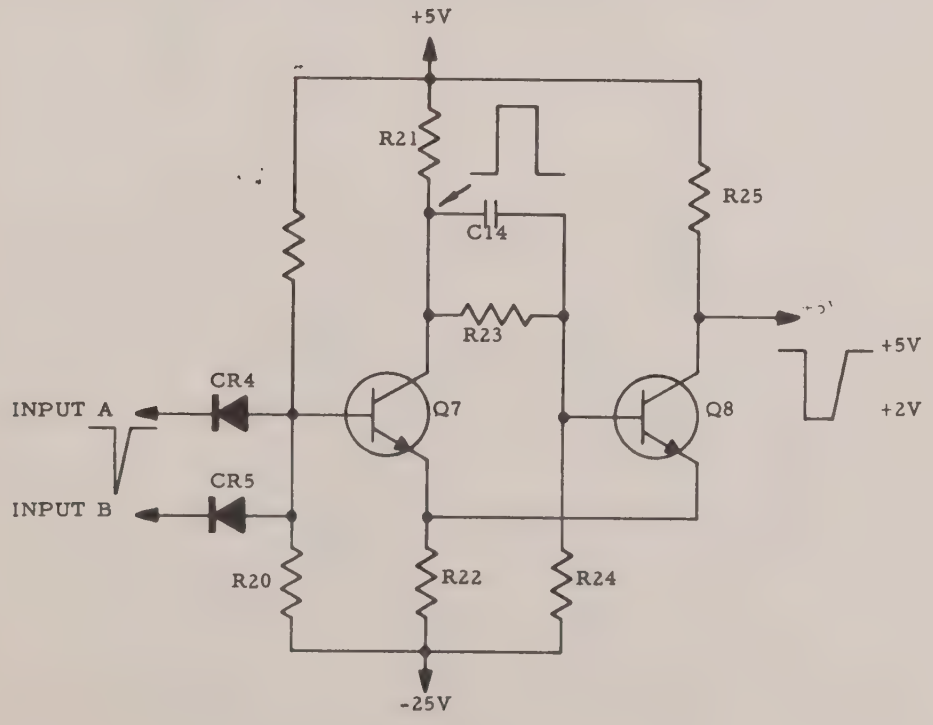


Figure 3-4. Simplified Schmitt Trigger.

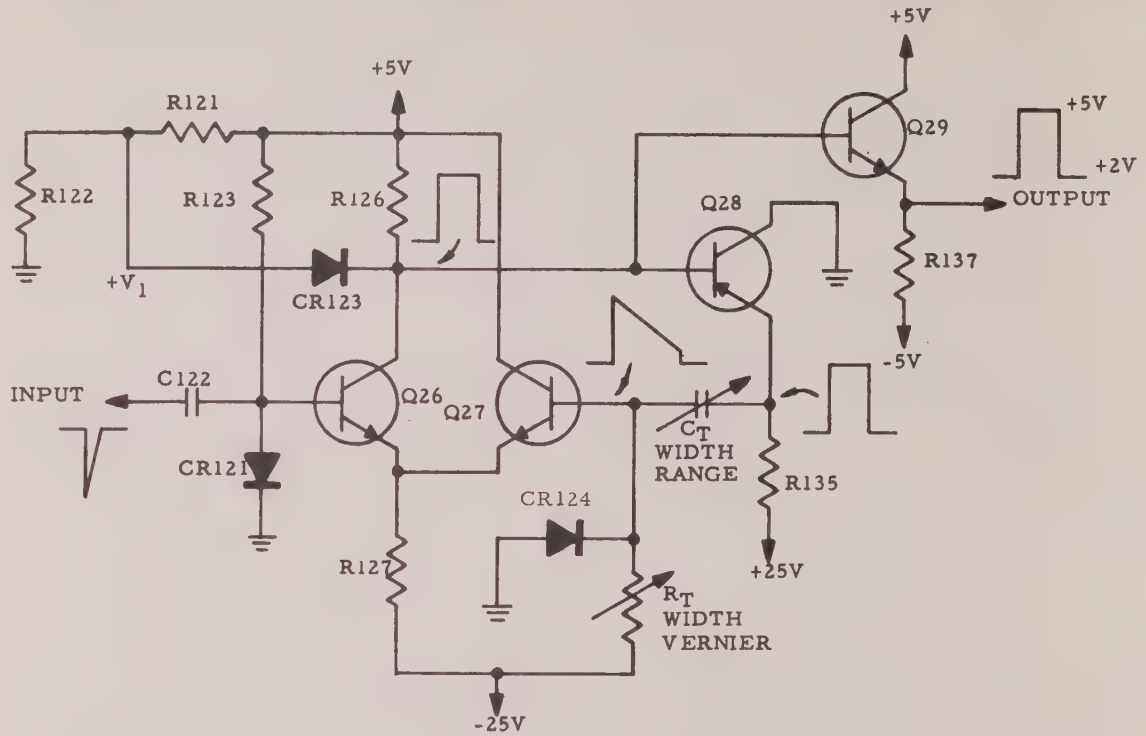


Figure 3-5. Simplified One Shot Circuit

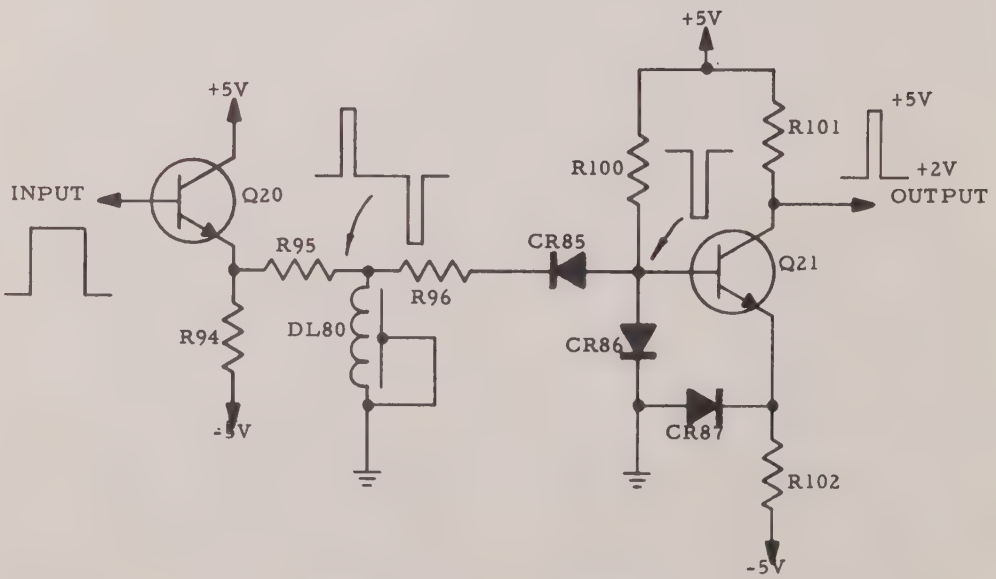


Figure 3-6. Pick Off Amplifier

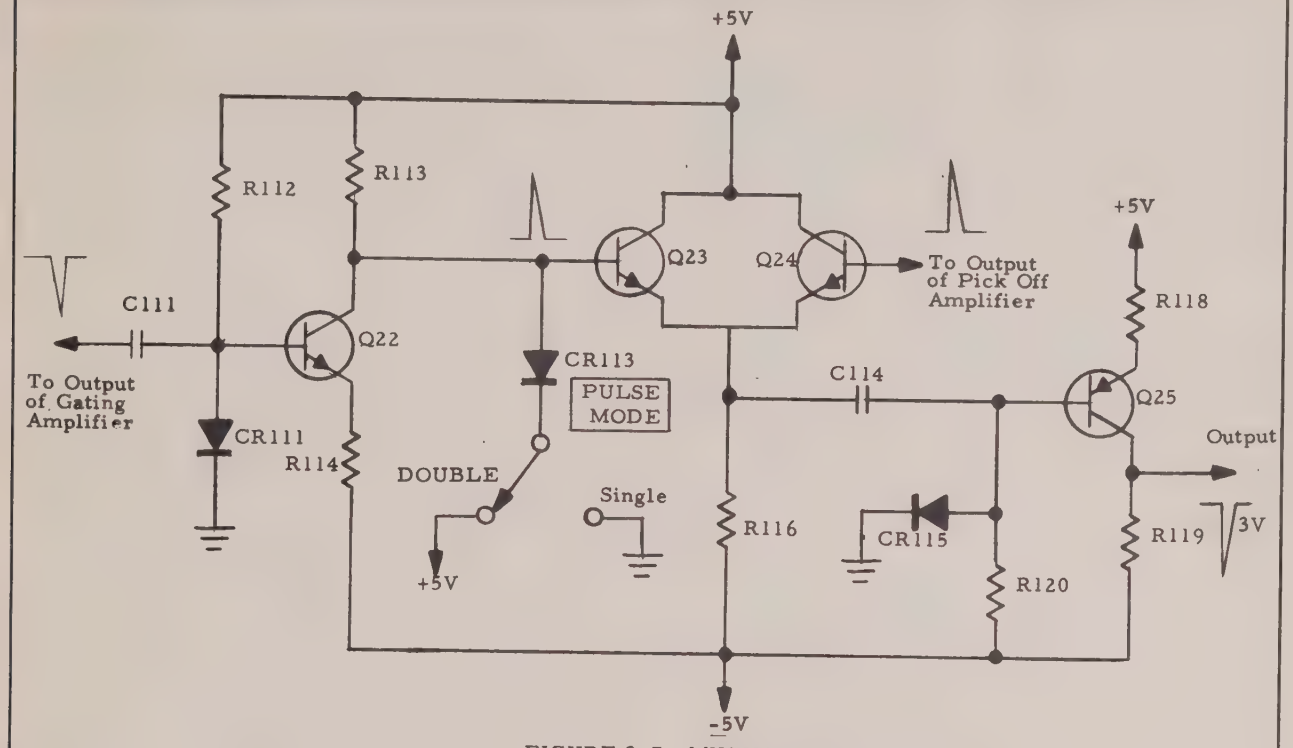


FIGURE 3-7. MIXING AMPLIFIER

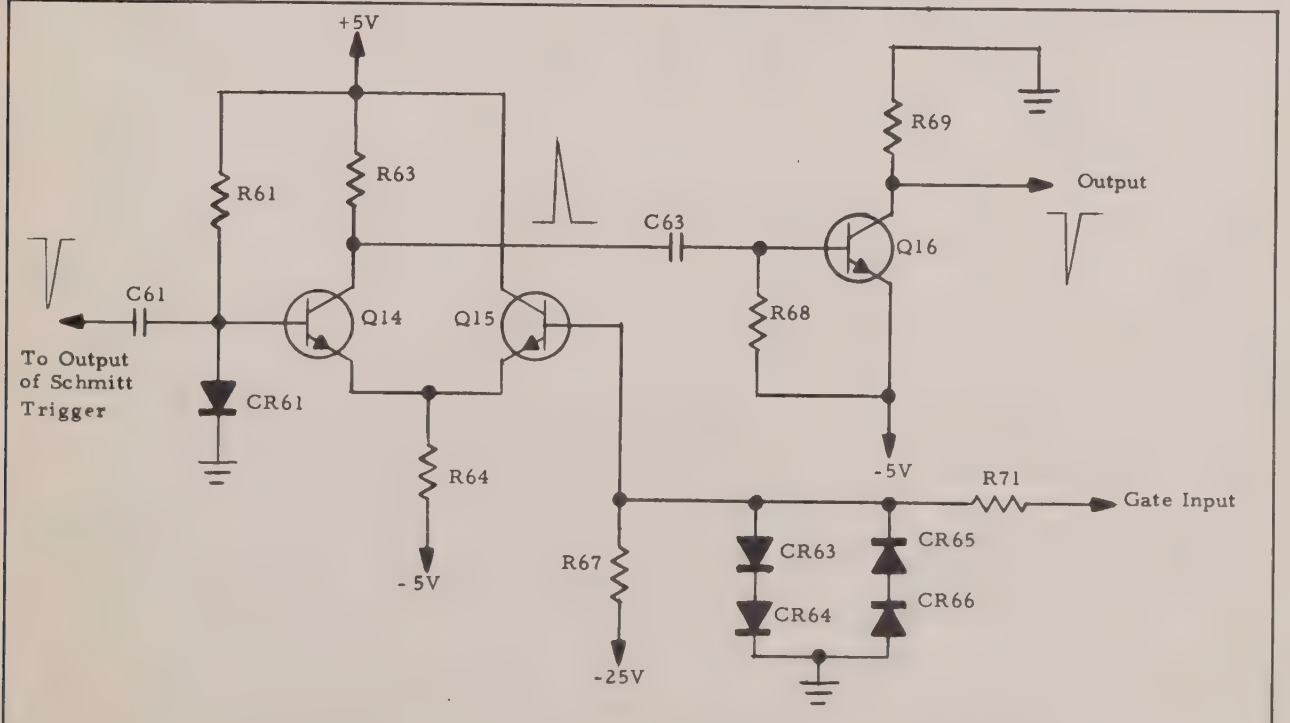


FIGURE 3-8. GATING AMPLIFIER

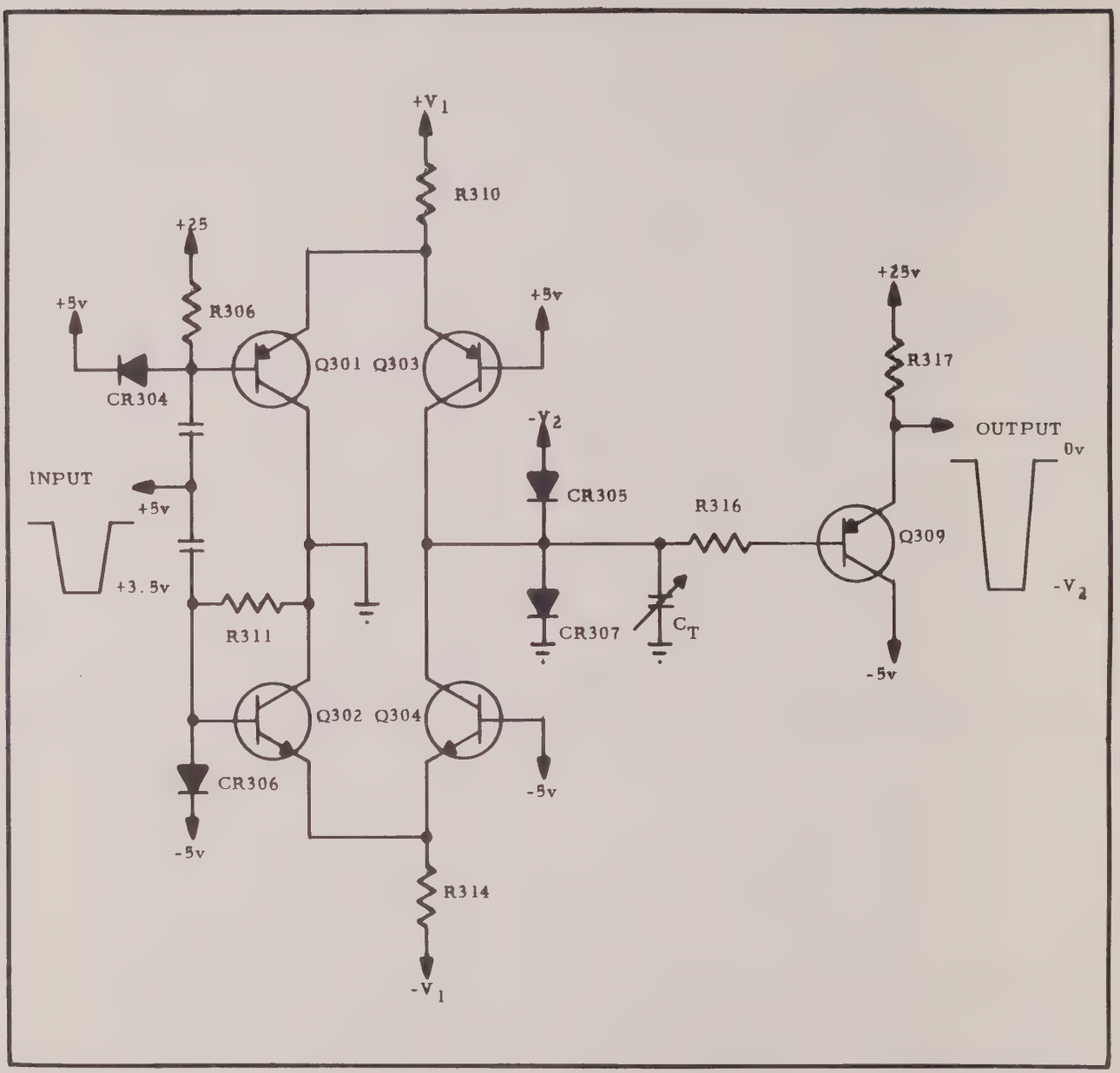


Figure 3-9
Rise & Fall Circuit

driving pulse with the desired transition times for the output amplifiers. The control of the transition times is accomplished by the charging and discharging of a capacitor with two current sources. Because the charging and the discharging is done with current sources, the resulting leading and trailing edges are a linear function of time. The magnitudes of the current sources are goverened by the Transition Time verniers. The value of the capacitor being charged and discharged is determined by the Transition Time Range Control. Refer to Figure 3-9 and drawing number 40000-103 for the following circuit description.

The transition time determining circuitry is composed of Q303 and Q304. In the quiescent state, Q303 is ON and Q304 is OFF. The collector current of Q303 flows through CR307 and this clamps the collector potential of Q303 at 0v. A negative input signal cuts off Q303 and turns on Q304. The collector current of Q304 discharges CT and the collector voltage of Q304 decreases until it reaches $-V_2$. At this point, CR305 conducts and clamps the voltage to $-V_2$. The collector current of Q304 now flows through CR305. When the input signal reutrns back to 0v, Q304 is turned off and Q303 is turned on. The collector current of Q303 charges CT and its voltage rises until it is clamped to 0v by CR307. This completes one cycle of operation.

The collector current of Q303 is determined by $+V_1$, R310, and the input voltage. The collector current of Q304 is determined by $-V_1$ and R314. Note that the collector currents of both Q303 and Q304 are independent of their collector voltages and load. Hence, Q303 and Q304 can be considered as current sources and the voltage rise across CT will be linear as seen below:

The voltage across a capacitor is

$$V = \frac{1}{C}\int i\,dt$$

If i is a constant, then

$$V = \frac{it}{C}$$

which shows that V is a linear function of time. time.

The transition time vernier is accomplished by varying the values of $+V_1$ and $-V_1$. Transition Time Range Control is accomplished by varying the value of CT.

3.2.10 Output Amplifiers

The output amplifiers consist of two current drivers working into 50 ohm loads. Each current driver supplies 200 ma which is constant and independent of load impedance and attenuator settings. Constant current output has the advantage of built-in short circuit protection because no more current flows in a shorted output than when not shorted. The total circuit for each polarity consists of four current drivers in parallel with each driver supplying 50 ma. Each section operates as follows.

In the static state, the base of Q1 is more negative than $+V_b$ by the drop across CR1 and its emitter more negative still by the base-emitter drop. This places the emitter of Q2 more negative than its base and holds Q2 cutoff.

Upon the application of a positive going signal to the base of Q1, the base-emitter diode of Q2 is forward biased, and a current of magnitude $\frac{\text{E Signal}}{\text{R Emitter}}$ flows in the emitter of Q2. A current of approximately this magnitude * flows in the collector of Q2 and consequently into the load R_L. As the positive pulse input subsides, the circuit reverts to the static state.

The negative pulse output circuit operates in the same manner, however, voltage polarities are reversed and Q1 is PNP, Q2 NPN.

The output current of 200 milliampers provides 10v when delivered into 50 ohms. A constant impedance attenuator is used to provide voltage outputs of less than 10v.

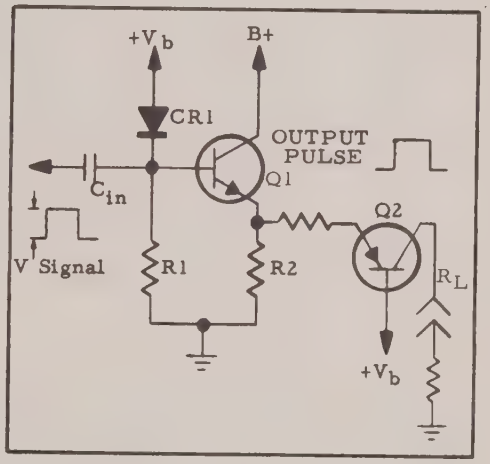


Figure 3-10. Simplified Output Driver.

To provide good waveshape and to minimize pulse aberrations, Q2 is operated at near saturation when the output voltage has reached 10 volts. This is accomplished by adjusting +Vb such that it is slightly more positive than +10V. At this value, the collector to base voltage is less than one volt. Any perturbation which tends to cause the output voltage to rise above +10 volts will be clamped by the transistor itself. In addition, by making the collector to base voltage small, the gain bandwidth product of Q2 is reduced. Therefore, perturbations which would tend to occur in the flattop portion of the output pulse will be clamped out by Q2. The value of $+V_b$ is very critical and should not be adjusted unless the output transistors are changed. The operation of the negative amplifier is identical except that the polarities are reversed and that NPN transistors are changed for PNP transistors.

3.2.11 Baseline Offset Circuit

The purpose of this circuit is to vary the baseline of the output pulses. This is accomplished by "squirting" current into the load impedance by means of current drivers tied to the output BNC

*** Alpha times emitter current flows in the collector circuit. As alpha is on the order of 0.95 to 0.98, this is nearly the same current that flows in the emitter circuit.**

connector, one for driving the baseline positive and one for driving the baseline negative. Since the drivers are connected after the attenuators, the baseline of the outputs are independent of the attenuator settings. The operation of both the positive and the negative baseline offset circuits are identical except for the reversed polarity of voltages and transistors. Refer to drawing 40000-118 for the following discussion of the circuitry.

The negative baseline offset circuit is shown in the right hand position of drawing 40000-118. The value of the baseline is controlled by R643 (Negative Baseline Offset Control). The voltage output of R643 is equal to the value of the baseline. Q343 and Q344 form a difference amplifier which compares the baseline of the negative output against the output of R643. In normal operation, these two voltage levels should be within 100 millivolts of each other. Assume that R643 has been adjusted to provide an output of -2 volts and that the baseline has been initially set for 0 volts. This means that the base of Q344 is now more positive than the base of Q343. For this condition, Q344 will be on and Q343 will be off. Collector current of Q344 flows through the base of Q345 and causes Q345 to turn on. The collector current of Q345 flows through the emitter of Q346 and turns it on. In addition, the Q345 collector current also flows through CR642 and causes Q348 and Q349 to turn off. Q348 and Q349 are the positive current drivers which cause the baseline to go positive.

The collector current of Q346 flows through the base of Q347 and causes it to turn on. Q347 is a negative current driver and it acts as a current sink. This causes the baseline to go negative. The baseline is peak detected by CR648 and C647; therefore, the voltage of C647 will follow the baseline. The purpose of the ferrite beads and L641 between the baseline offset circuit and the negative output is to isolate the capacitance of the baseline offset circuit from the negative output. The voltage at C647 is coupled back to the base of Q344 by means of R648. When this value goes slightly more negative than the output of Q343, Q344 will be turned off. This then turns off Q345 and Q346. Q345 turning off allows Q348 and Q349 to turn on again. Q346 turning off causes Q347 to turn off. The turning on of Q348 and Q349 injects a positive current into the output and causes the baseline to go positive. When the baseline goes above the output of R643, Q343 is turned off and Q344 is turned on. The process is repeated over and over again with the result that the baseline is always held at a value which is very close to the output of R643. The operation of the positive baseline offset circuit is identical except that voltage polarities and transistor types are interchanged. When the Baseline Offset Switch is in the 0 volts position, the positive and the negative current drivers are disconnected from the output. However, the collector voltage of Q348 will still be equal to the output of R643 because the difference amplifier now compares the collector voltage of Q348 and the output of R643.

3.2.12 Baseline Offset Auxiliary Power Supply

The purpose of this circuit is to provide the base voltage, V_{cl}, for the output transistors and the collector voltage, V_{cc}, for the emitter followers which drives the output transistors. As it was explained in paragraph 3.2.10, the magnitude of the base voltage on the output transistors is extremely important for correct operation and minimum pulse distortion. This means that the base voltage must be adjustable. Additionally, in order to keep the collector to the base voltage of the output transistors constant, the base voltage must be made to track the output baseline voltage. This is because the output baseline voltage is the collector voltage for the output transistors. Refer to drawing number 40000-118 for the description of the negative auxiliary power supply. The operation of the positive power supply is identical except for reversed polarities.

The value of the baseline is sampled at the input to the negative attenuator by the peak detector composed of CR661 and C661. This means that the voltage across C661 will always follow the baseline voltage. The voltage across C661 is fed to the base of a paraphase amplifier Q350. Assume that the baseline voltage is suddenly changed from 0 volts to -2 volts. If V_{cl} does not change correspondingly, the collector to base voltage will now be increased by two volts and the output waveshape will exhibit a significant increase in ringing and overshoot.

The negative voltage at the base of Q350 causes its emitter to go negative by the same amount. This is coupled to the base of Q353 by means of R666 and R667. Q353 is an emitter follower and therefore, its emitter voltage follows its base voltage. Hence, $-V_{cl}$ is changed the same amount and in the same direction as the baseline voltage. However, in order to minimize power dissipation and excessive collector to emitter voltage in the emitter followers driving the output transistors, the collector voltage of the emitter followers must also track the baseline voltage. As the base voltage of Q350 goes negative, its collector goes positive and causes the base current of Q351 to increase. This increases the base current of Q352 and as a result, collector current of Q352 also increases. The increase in collector current of Q352 results in $-V_{cc}$ going negative. The change in $-V_{cc}$ is coupled back to the emitter of Q350 by means of the Zener diode, CR662. When the change in $-V_{cc}$ equals the change in the output baseline, the circuit reverts back to its quiescent state.

SECTION IV

MAINTENANCE INSTRUCTIONS

4.1 PREVENTIVE MAINTENANCE

4.1.1 Preventive Inspection and Service

Inspection and service of a preventive nature will result in optimum performance and longer life of this instrument. Dust covers should be removed at regularly scheduled intervals to permit inspection for dust, tarnish, corrosion, loose nuts and bolts (especially those serving as electrical conductors), loose cables and fuses, charred insulation, scorched resistors and broken wiring. Discoloration of the printed circuit board, due to heat, does not affect the board's electrical properties and may be disregarded in most cases.

4.1.2 Minor Repairs

The operator should be thoroughly acquainted with the instrument's circuit theory and component location before attempting repair. In all cases, setting and adjustment of controls should be checked in order to verify that difficulties encountered are actually caused by malfunction and not by operation outside of specifications. Check transistors in suspected circuits prior to conducting extensive tests on other components. A check of the important waveforms as shown on schematics will be of great assistance.

4.1.3 Recalibration

This instrument was designed to provide maximum reliability and stability. To insure that accuracy remains within stated limits, we suggest that calibration be checked after every 200 hours of operation. See Section 4.5 for calibration check. If the unit is used intermittently, calibration should be checked every three months. Complete instructions for calibration are given in this manual.

4.2 PARTS REMOVAL AND REPLACEMENT

4.2.1 General

This instrument is sturdily built and easily accessible. Removal of most parts is so simple that explanations are unnecessary. However, some parts are more easily removed if a definite procedure is followed. Replacement of some parts will also require partial recalibration. Refer to Section 4.4 of this manual for calibration instructions.

4.2.2 Removal of Dust Covers

The dust covers are held in place by small screw-head fasteners. To remove, turn the fasteners a quarter turn counterclockwise with a common screwdriver. To remove the top dust cover: (1) loosen the four fasteners in the sides of the bottom dust cover; (2) remove the four fasteners on the sides of the top dust cover; (3) loosen the two fasteners on the top of the dust cover; and (4) lift the cover up and off.

To remove the bottom dust cover: (1) turn the instrument upside down: (2) remove the four fasteners on the sides of the bottom cover: (3) loosen the four fasteners on the bottom of the cover; and (4) lift the cover up and off.

4.2.3 Replacement of Power Transistors

The power transistors which are mounted to the rear panel must have a thin film of silicon grease (such as Dow-Corning DC-4) applied to their common contact surfaces.

4.2.4 Soldering Considerations

Although printed wiring is quite vulnerable to heat excesses, a great deal of resoldering can be done on a single joint if care is taken. A 35-watt wedge tip or pointed tip iron and 60-40 rosin core solder are quite effective. Where both sides of the board are accessible apply the tip of the iron (on the side opposite the component) directly to the solder fillet and pull gently on the pigtail with pliers from the opposite side. Where both sides of the circuit board are not accessible, the component lead will be fed through the board through an eyelet. Apply the iron tip to the eyelet and pull the pigtail out with the pliers. To insert a new component, clean out the hole with a sharp object (it may be necessary to apply more heat) and insert the new component, soldering in the old place.

4.3 TROUBLESHOOTING PROCEDURE

Before any troubleshooting is attempted the front panel controls should be checked for proper setting. You may wish to refer to paragraph 3.2, "Operating Considerations" which details many of the limitations of the instrument and describes the performance to be expected. After you have ascertained that a trouble does exist, you may continue according to the procedures outlined in this section.

Many apparent malfunctions are due to improper calibration of one or more of the circuits, and often a transistor is replaced that requires recalibration. If you suspect that a circuit is miscalibrated refer to Section 4.5 of this manual, which describes a procedure for determining calibration status. Section 4.4 provides a detailed calibration procedure.

Whenever trouble occurs check the power supply voltages. This test may be done by following paragraph 4.4.3 of the "Calibration Procedure". It may be assumed that the power supplies are functioning properly if the output and ripple voltages are correct.

When malfunction can be attributed to a particular circuit, perform a complete visual inspection in that area. See Figure 4-1 for the location of circuits. Frequently visual inspection reveals the effects of the trouble (such as burned resistors) rather than the cause. However, these effects may give clues as to the actual cause. Care should be taken to find the real cause.

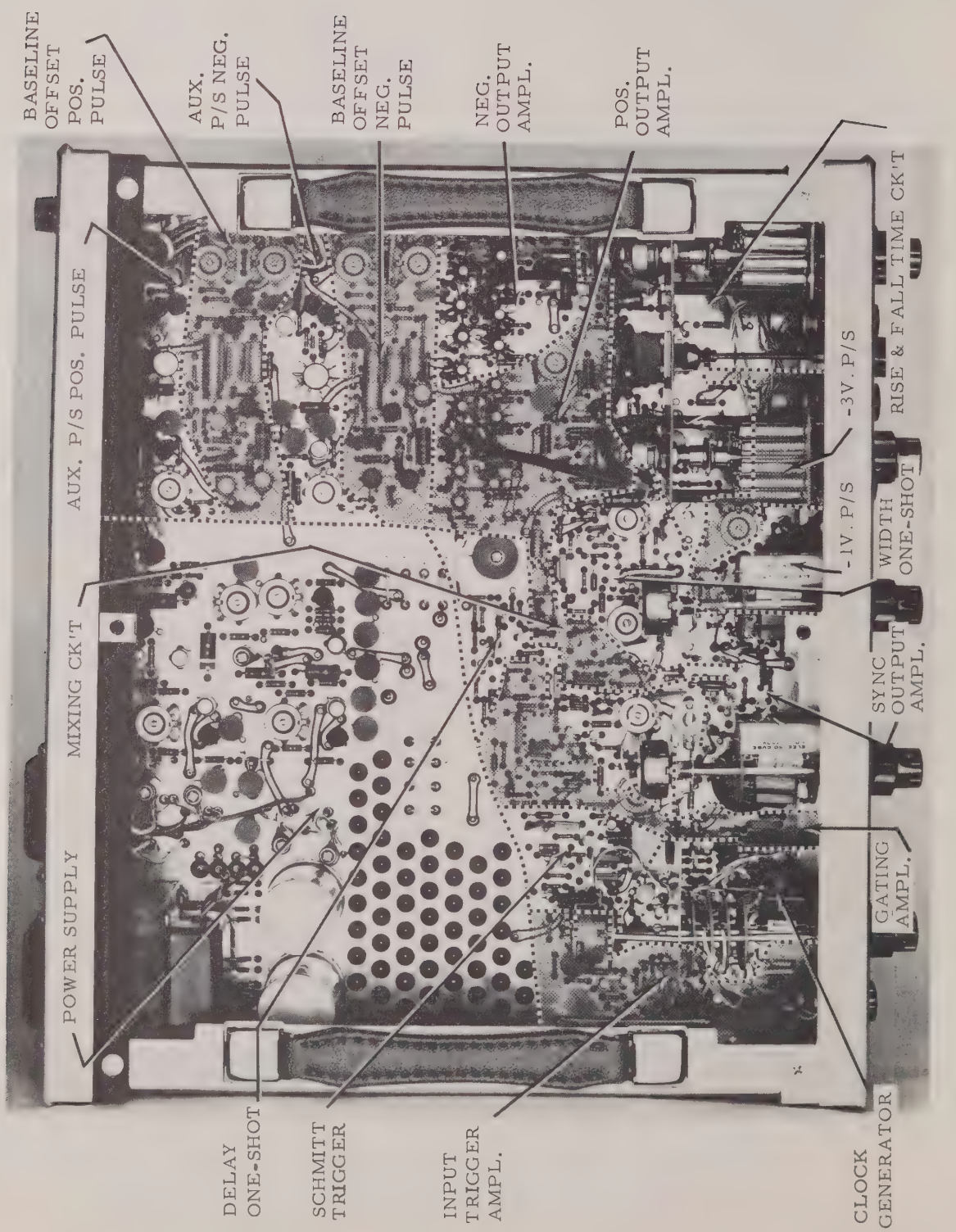


Figure 4-1. Circuit Locations

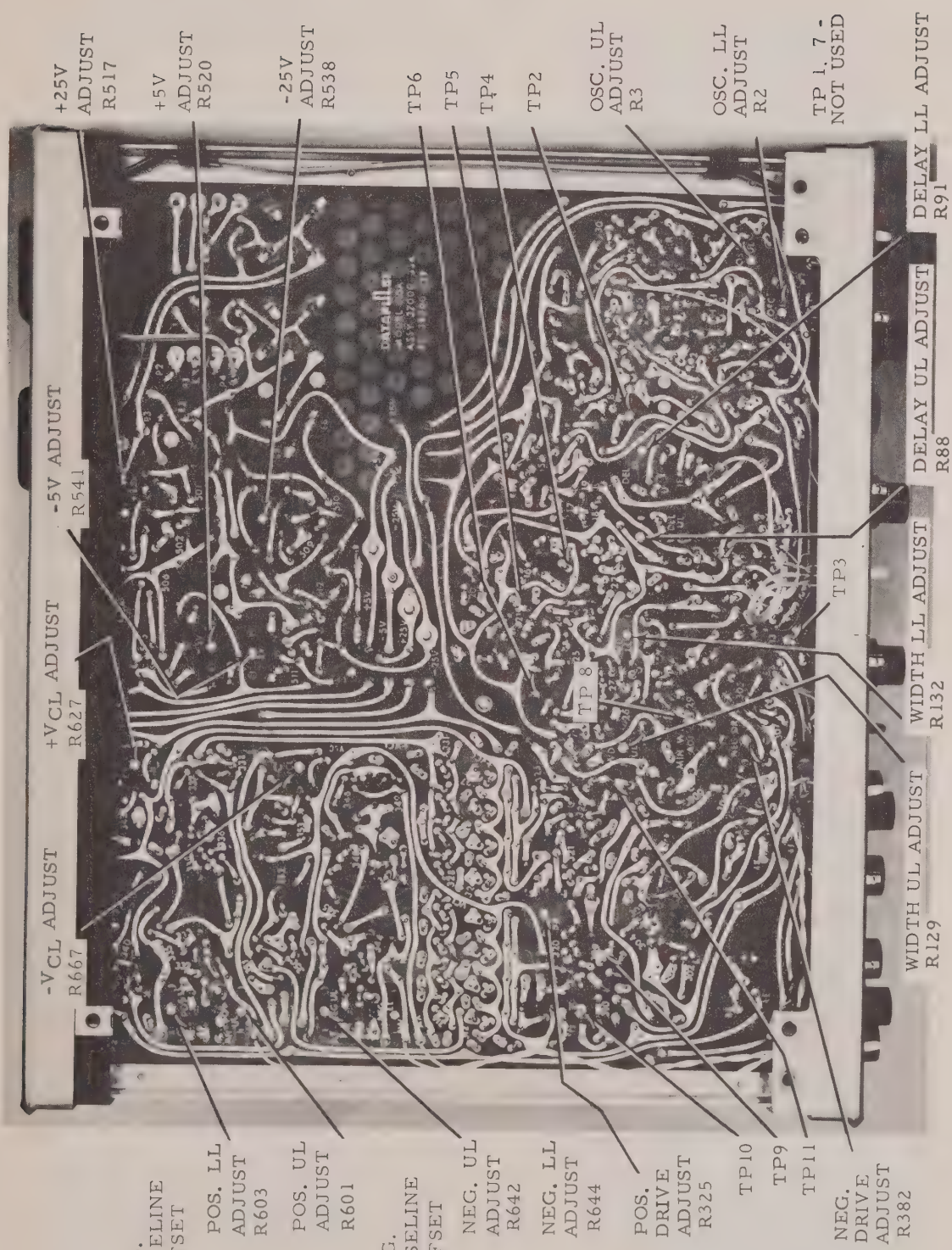


Figure 4-2. Adjustment & Test Point Locations

The most difficult circuit to troubleshoot in the Model 110 is the Baseline Offset Circuit and its auxiliary power supply. The reason for this is that the baseline offset circuitry forms a closed loop system. To facilitate troubleshooting, always break the feedback loop at a point in which the problem can occur. For instance, assume that the negative baseline hangs up at +10 volts and cannot be decreased. In order for this to occur, Q348 and Q349 must be on. This means that either these transistors must be shorted or that the control circuitry for their bases are out of "whack". To determine which of the former conditions is the case, simply tie a diode (1N914 or equiv.) from the base of Q348 to the emitter of Q345 (with the anode of the diode at the emitter of Q345). If the output baseline drops, then Q348 and Q349 must be good. The trouble then lies in Q345, Q346, Q344 or Q343. Next step should be to check the output of R643 and determine whether it will go negative or not. If R643 is ok, then the base of Q343 will be more negative than Q344. That means that Q344 will be on and that base current of Q345 will flow through Q344. To check for this, measure the base to emitter voltage of Q345 with a voltmeter, the base of Q345 should be approximately 0.7 volt more negative than its emitter. If this is not the case, then Q345 or Q344 or both must be bad. If Q345 and Q344 are good, then check the base to emitter of Q346 with a voltmeter. The base of Q346 should be 0.7 volts more positive than its emitter. If this is good, then the trouble must be in Q347 and its associated circuitry.

Another problem that can occur is that as the baseline voltage is changed, the distortion on the output pulse increases. This condition indicates that the baseline offset auxiliary power supply is not tracking with the baseline voltage. In verifying this, put a voltmeter on the V_{c1} output and check whether or not it is following the output baseline. If not, refer to section 3.2.12 regarding the operation of this circuit and check for possible areas of trouble. The best method in troubleshooting is to thoroughly understand the operation of the circuit and then to systematically isolate the problem.

4.3.1 Troubleshooting the Power Supplies

Almost all power supply failure may be typified by collector to emitter shorts (transistors) and anode to cathode shorts (rectifiers and zener diodes). These conditions are easily detected "in circuit" with an ohmmeter because they measure zero resistance in both directions.

4.3.2 Troubleshooting the Pulse Circuits

Once it has been ascertained that the power supplies are functioning correctly, the most straight forward method of tracking down a trouble is to begin at test point #1 and proceed through the instrument comparing waveforms to those listed on the schematic. When the proper waveform is distorted or missing entirely, then a comparison of voltage and resistance readings to those listed in Table 4-1. will generally narrow the trouble down to one of a very few components. Because of the "straight through" nature of the instrument circuitry, most troubles will manifest themselves as complete absence of output pulses or invariability of one or more of the pulse parameters. In the later case a good indication is given as to which circuit to suspect.

4.4 CALIBRATION PROCEDURE

4.4.1 Equipment Required

a. Triplett 630 VOM, or equivalent.

b. Tektronix Model 561 Sampling Scope or equivalent.

c. Tektronix Model 543 Scope with CA Plug-in or equivalent.

d. Datapulse Model 109 or Model 110 Pulse Generator or equivalent.

e. Hewlett-Packard Model 202C Oscillator or equivalent.

f. Variable voltage transformer, 0-140v, 60 cps, 6 amp.

g. Resistor, WW, 100Ω, 10w.

4.4.2 Power Supply Section

a. Disconnect all voltage jumpers from power supply to front end and output amplifier sections.

b. Disconnect one end of R511 and R532.

c. Adjust variac for 115 vac and plug in Model 110.

d. Adjust R517 for +25v, ±3%.

e. Adjust R520 for +5.5v, ±5%.

f. Load +25v to ground with 100Ω. +25v should not change more than ±0.5v.

g. Adjust variac so that ac input to Model 110 varies from 105v to 125v. +25v should not change more than ±0.5v.

h. Load +5.5v to ground with 100Ω. +5.5v should not change more than ±0.5v.

i. Adjust R538 for -25v, ±3%.

j. Adjust R541 for -5.5v, ±5%.

k. Load -25v to ground with 100Ω. -25v should not change more than ±0.5v.

l. Adjust variac so that ac input to Model 110 varies from 105v to 125v. -25v should not change more than ± 0.5v.

m. Load -5.5v to ground with 100Ω. -5.5v should not change more than ±0.5v.

n. Make certain all 100Ω loads are disconnected from power supply.

4.4.3. Front End Section

Connect voltage jumpers from power supply to front end section.

4.4.3.1 Clock Generator Adjustment

a. Monitor TP2 with Tektronix 543 scope.

b. Set M110 Repetition Rate Control to 4 mc position.

c. Waveform at TP2 should be negative pulse from +5.5v to +2v with rise and fall times faster than 20 nanosec.

d. Turn Repetition Rate Vernier Control, R4, to maximum clockwise position.

e. Adjust R3 for frequency of 4.4 mc (0.23 μs).

f. Turn Repetition Rate Vernier Control, R4, to maximum counterclockwise position.

g. Adjust R2 for frequency of 360 kc. (2.8 μs).

h. Repeat Steps a through g.

i. Check the upper and lower limits of each repetition rate range. Make certain that the ranges overlap each other. If the ranges do not overlap, readjust R3 and R2 an amount required for overlapping. If R2 and R3 have to be changed significantly, check timing capacitor tolerances.

j. Monitor TP2 with Tektronix 561 scope using P6035 passive probe (5k input Z).

k. Set Repetition Rate Control to 40 mc position. Turn 40 mc Repetition Rate Vernier, C5, to maximum clockwise position.

l. Adjust C4 for frequency of 40 mc.

m. Turn 40 mc Vernier Control to maximum counter-clockwise position. Frequency should be less than 4.3 mc. If frequency is greater than 4.3 mc, R5 should be increased until the frequency is less than 4.3 mc. If R5 is changed, C4 must be readjusted.

n. Turn Repetition Rate Control to -EXT position. Turn EXT Sensitivity Control (R32) to maximum clockwise position. Set Input Impedance Z Switch (S31) to the 50Ω position.

o. Adjust the negative output of test pulse generator for 1.5v amplitude. Couple the output to Trigger Input of M110 under test with 50Ω coaxial cable. Vary the frequency of test pulse generator from 4 mc to 40 mc. The M110 under test should trigger reliably through the entire range.

p. Repeat step o only, using a positive pulse with the Repetition Rate Control set to +EXT position. Ascertain that the unit will trigger reliably from 4 mc to 40 mc with 1.5v positive pulse.

q. Turn Input Z Control (S31) to 500Ω position. Set output of H.P. 202C Oscillator for 1.5v rms and check M110 for reliable triggering from 4cps to 1 kc in both the -EXT and +Ext positions of Repetition Rate Control.

r. Turn Repetition Rate Control to Single Cycle position. Verify that one and only one pulse is generated at TP2 for every depression of the Single Cycle Pushbutton.

4.4.3.2 Sync Output Amplifier Checkout

a. Feed sync output of M110 to 50Ω input of Tektronix 561 (set trigger mode of 561 to -Int. Pos.).

b. Vary frequency of M110 from 4mc to 40 mc.

c. The waveshape should be a negative going pulse of at least 2v amplitude with rise and fall times less than 10 nanosec. The amplitude of the pulse should not vary more than 20% from 4 mc to 40 mc. The width of the pulse should be approximately 25 nanosec and will vary with frequency. Observe the baseline and ascertain that no spurious signals (greater than ±0.1v) appear as the frequency is varied from 4 mc to 40 mc.

4.4.3.3 Gating Circuit Checkout

a. Monitor TP4 with Tektronix 543.

b. Set frequency of M110 for 4 mc.

c. Waveform at TP4 should be a negative going signal from 0v to -5v of approximately 15 nanosec in width. The rise and fall of the signal should be less than 10 nanosec.

d. Feed positive output of test pulse generator to the gate input of M110 under test. Adjust frequency and width of test pulse generator for 1 kc square wave. Trigger scope with sync output of test pulse generator.

e. Adjust Amplitude Control of test pulse generator for +3.5v. The waveform at TP4 should be a burst train

of pulses with a burst rate of 1 kc and a pulse rate of 4 mc.

f. Decrease amplitude of tested M109 or M110 to +1.5v. The waveform at TP4 should now be a continuous pulse train of 4 mc.

4.4.3.4 Delay One-Shot Checkout

a. Monitor emitter of Q20 with P6035 probe of Tektronix 561.

b. Adjust frequency of M110 for 100 kc. Set Delay Control to 5 μs position. Turn Delay Vernier to maximum counterclockwise position.

c. Adjust R91 so that positive (4v) pulse at emitter of Q20 is 0.45 μs wide (50% amplitude points).

d. Set Delay Vernier of M110 to maximum clockwise position.

e. Adjust R88 so that pulse width at emitter of Q20 is 5.5 μs.

f. Repeat Steps c through e.

g. Set Delay Control of M110 to 0.05μs position. Turn Delay Vernier to maximum clockwise position.

h. Adjust C85 for pulse width of 50 nanosec at emitter of Q20.

i. Put P6035 probe of Tektronix 561 on TP5. There should be a positive pulse, from +2v to +5v, of 10 nanosec width with rise and fall times of approximately 10 nanosec.

j. Vary Delay Vernier from maximum counterclockwise position to maximum clockwise position. Observe pulse amplitude as delay is varied and make certain that it does not vary by more than 15%. In addition, the pulse should move smoothly as a function of delay vernier and no "skipping" should occur.

k. Monitor emitter of Q20 with Tektronix 543 scope. Check the limits of each delay range. Make certain that the ranges overlap each other. If there are "holes" in the delay ranges, adjust either R88 or R91, or both to eliminate "holes." In the event that R88 or R91 have to be changed significantly (greater than 15%) from their original setting, check the values of the timing capacitors.

4.4.3.5 Mixing Circuit Checkout

a. Adjust M110 for frequency of 4 mc. Set Delay Controls for minimum delay (both controls maximum counterclockwise). Flip Pulse Mode Switch to Single Pulse position.

b. Monitor TP6 with Tektronix 561 and P6035 probe.

c. Adjust C114 for 10 nanosec wide negative pulse of 3v amplitude.

d. Flip Pulse Mode Switch to Double Pulse position. There should be two pulses appearing at TP6. Adjust the Delay Vernier Control so that the two pulses are separated by 25 nanosec (leading edge to leading edge).

e. Adjust C111 so that the first and second pulses are of approximately equal amplitude. C111 and C114 interact slightly with each other; therefore, both must be adjusted.

f. Turn Delay Vernier of M110 in clockwise direction and note amplitude of both pulses as delay is advanced. The amplitudes should not change by more than 15%. If amplitudes do change more than 15%, readjust C111 and C114.

4.4.3.6 Width One-Shot Checkout

a. Adjust M110 for 100 kc frequency and minimum delay. Set Pulse Width Control to 5 μs position. Monitor TP7 with Tektronix 561 and P6035 probe.

b. Turn Width Vernier Control to maximum counterclockwise position. Adjust R132 for positive 3v pulse of 0.45 μs (50% amplitude points) at TP7.

c. Turn Width Vernier Control to maximum clockwise position. Adjust R129 for 5.5 μs pulse width at TP7

d. Repeat Steps b and c.

e. Set Width Control to 0.05 μs position. Turn Width Vernier Control to maximum clockwise position. Adjust C126 for pulse width of 50 nanosec at TP7.

f. Vary Width Vernier Control from maximum counterclockwise position to maximum clockwise position. Observe amplitude of pulse as width is varied and make certain that it does not vary by more than 15%. In addition, the pulse width should increase smoothly without hesitation or skipping.

g. Observe TP8 with Tektronix 561 and P6035 probe. Turn Width Controls of M110 to minimum width position. Adjust C134 for negative pulse of approximately 4v amplitude and 10 nanosec width.

h. Monitor TP7 with Tektronix 543. Check the limits of each width range. Make certain that the ranges overlap each other. If "holes" exist in the width ranges, adjust either R129 or R132, or both. The amount of readjustment required should be slight; if this is not true, change values of timing capacitors.

4.4.4 OUTPUT AMPLIFIER SECTION

NOTE: For optimum performance, calibration of the output circuits require the use of a high bandpass oscilloscope such as the HP Model 185B. The rise time and pulse corner frequencies are sufficiently above the response of a general purpose oscilloscope; therefore, waveform abberations may be present which will not be apparent when viewed on the slower scope. A general purpose oscilloscope is, however, sufficient for "coarse" adjustment. The adjustment procedure is as follows.

Connect voltage jumpers from power supply to the output amplifier section of main printed circuit board. Trigger oscilloscope with sync output of M110. Set the M110 controls to the following:

a. Repetition Rate Control: 4 Mc
b. Repetition Rate Vernier: Extreme ccw.
c. Pulse Delay Control: 50 ns.
d. Pulse Delay Vernier: Midway
e. Pulse Width Control: 50 ns.
f. Pulse Width Vernier: Extreme cw.
g. Positive Amplitude Control: 10v.
h. Positive Amplitude Vernier: Extreme cw.
i. Negative Amplitude Control: 10v.
j. Negative Amplitude Vernier: Extreme cw.
k. Mode Switch: Single Pulse
l. Transition Time Range: 5ns.
m. Leading Edge Control: Extreme cw.
n. Trailing Edge Control: Extreme ccw.
o. Positive Baseline Switch: GRD
p. Negative Baseline Switch: GRD

4.4.4.1 Negative Output Amplifier Checkout

a. Connect negative output of M110 to sampling scope through 10:1 attenuator with gain of vertical amplifier set for 200 mv/cm.

b. Adjust Negative Amplitude Dr. Control (R317) for output amplitude of 10v.

c. Adjust $-V_{CL}$ Control (R667) for minimum overshoot and pulse aberration. See Figure 2-1 for correct adjustment.

d. Set Negative Baseline Switch to VAR position.

e. Turn Negative Baseline Offset Vernier to the +10v position

f. Adjust Negative UL Control (R642) for an output baseline of +10v.

g. Turn Negative Baseline Offset Vernier to the -2v position.

h. Adjust the Negative LL Control (R644) for an output baseline of -2v.

i. Repeat steps e through h until the levels are correct.

j. Vary the leading and trailing edge verniers. The leading and trailing edges of the output pulse should vary linearly as the controls are adjusted.

4.4.4.2 Positive Output Amplifier Checkout

a. Connect positive output of M110 to sampling scope through 10:1 attenuator with gain of scope set for 2v/cm.

b. Adjust Positive Amplitude Dr. Control (R325) for output amplitude of 10v.

c. Adjust $+V_{CL}$ for minimum overshoot and pulse aberration. Refer to Figure 4-2 for correct adjustment.

d. Set Positive Baseline Switch to VAR position.

e. Turn Positive Baseline Offset Vernier to the -10v position.

f. Adjust Positive LL Control (R603) for an output baseline of -10v.

g. Turn Positive Baseline Offset Vernier to +2v position.

h. Adjust the Positive Ul Control (R601) for an output baseline of +2v.

i. Repeat steps e through h until the baseline levels are correct.

j. Vary the leading edge and the trailing edge verniers. The leading and trailing edge of the pulse should vary linearly as the controls are varied.

4.4.5 Final Checkout

a. Connect negative output of M110 to sampling scope as in step 4.1a.

b. Adjust the pulse width for 150 ns.

c. Turn the leading and trailing edge controls to the maximum cw position. The transition time range control should be in the 5 ns position.

d. Adjust the Negative Amplitude Dr. Control (R250) so that the flat top of the output pulse has no notches.

e. Connect positive output of M110 to sampling scope as in step 4.2a.

f. Adjust the Positive Amplitude Dr. Control so that the flat top of the output pulse has no notches.

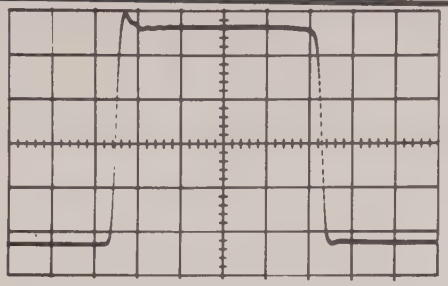
g. Switch through transition time controls and verify that no "holes" appear in either the positive or negative pulse from 5 ns to 500 μs.

h. Switch through the positive and negative controls and verify that no "holes" appear from 5 mv to 10v.

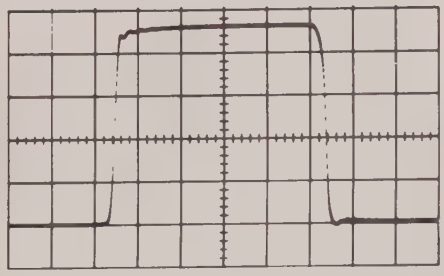
i. Check the operation of 40 mc. Verify that 40% ducy cycle is obtained at 40 mc.

j. Check the minimum rise and fall time on both the positive and negative pulses. Both the rise and the fall time should be less than 6 nanosec.

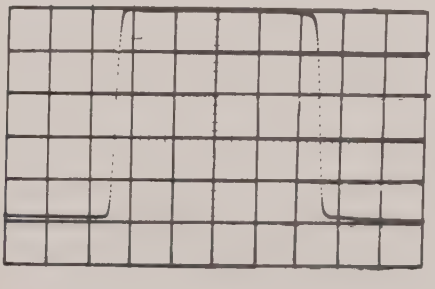
k. Check the operation of the double pulse mode of the minimum pulse delay setting. Vary the second pulse in respect to the first pulse from 25 ns to over 50 ns with the pulse width set for 10 ns. The two pulses should not differ by more than 25% throughout this range on both the positive and negative outputs. C111 and C114 may have to be readjusted to minimize the variations.



a. R667, $-V_{cl}$ Set Too High. Note Nearly 10% Overshoot With Full Amplitude Pulse.

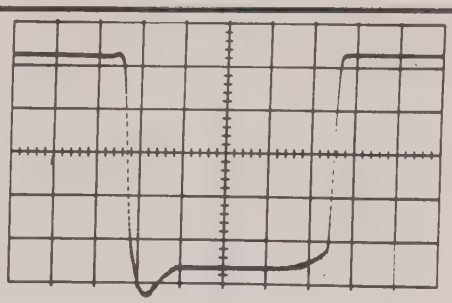


b. R667 Set Too Low. Note Reduced Amplitude, Ring At Leading Corner and Drooping Off, Caused By Storage Time, At Lagging Corner.

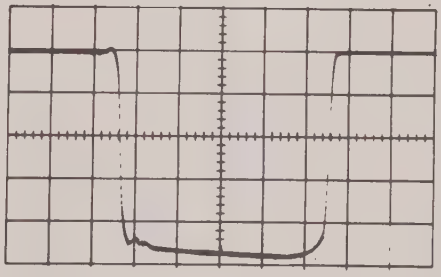


c. R667 Adjusted Correctly. Note Distinct Corners And Relative Lack of Aberrations.

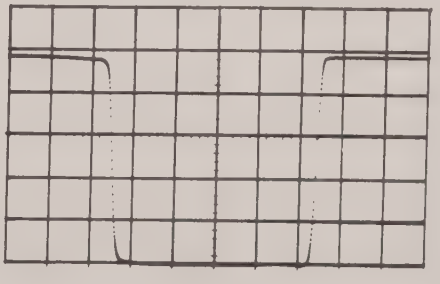
Figure 4-3. Adjustment of R667. Photographed from Tektronix 661 Sampling Oscilloscope. Horizontal Sensitivity 50 ns/cm. Vertical Sensitivity 2v/cm.



a. R627 $+V_{cl}$ Set Too High. Note Nearly 10% Overshoot With Full Amplitude Pulse.



b. R627 Set Too Low. Note Reduced Amplitude, Ring At Leading Corner, and Droop-Off, Caused By Storage Time, At Lagging Corner.



c. Correct Setting of R627. Note Distinct Corners on Waveform and Relative Absence of Aberrations.

Figure 4-4. Adjustment of R627. (Positive Overshoot) Photographed from Tektronix 661 Sampling Oscilloscope. 50 ns/cm and 2v/cm.

TABLE 4-1. VOLTAGES AND RESISTANCES

Unless otherwise noted, measurements were made under the following conditions:

Control Settings

Rep. Rate: 400ac; Vernier cw.
Pulse Delay: 0.5 μsec; Vernier ccw.
Pulse Width: 0.5 μsec; Vernier cw.
Amplitude: ±10v; Vernier cw.
Range: 5 nanosec.
Transition Time: Mid-range.
Baseline: at ground.
Negative, Positive, and Sync Output loaded with 50 ohms.

Input Impedance: 50 ohms.
Mode: Single Cycle.

Baseline Offset Switches in the 0v position.

All measurements were made with respect to ground.

All measurements were made with Triplett Model 630 Multimeter (20,000 ohms-per-volt). Note: Some meters have different internal wiring on resistance ranges. In this case, polarity of resistance readings may be reversed.

Resistance readings in second column indicate positive meter lead connected to ground.

The X10 resistance range was used unless noted. The X1k Scale was used for all resistances noted in K ohms. Use of higher ranges employ voltages that may be injurious to transistors. The voltages and resistances tabulated here are typical values. On some instruments the readings may differ considerably from this tabulation due to manufacturing tolerances and variations in component characteristics. This table should be used in conjunction with careful study of the schematic diagrams and the "Theory of Operation" section of this manual.

All voltages are dc.

All voltage measurements were made with 115v ac line voltage.

OUTPUT AMPLIFIER MODEL 110

TRANSISTOR	CIRCUIT	VOLTAGE			RESISTANCE					
		E	B	C	EMITTER		BASE		COLLECTOR	
	Variable Rise									
Q301	& Fall Time	.07	-.35	-5.5	60	2k	120	250	55	35
Q302		0	.07	1.5	0	0	60	2k	35	500
Q303		1.35	1.50	1.35	3k	100	500	200	350	35
Q304		-7.0	-7.1	1.35	500	500	2.5c	400	350	35
Q305		2.87	3.5	5.5	110	3.5k	200	45	50	4
Q306		-7.5	-8.2	-10.2	500	120	250	200	300	30
Q307		-3.8	-3.2	0	45	200	8.0	35	0	0
Q308		-1.15	-.50	0	350	180	2.5k	55	0	0
Q332		0	.25	1.35	0	0	6k	-	350	35
	Negative Output Amp.									
Q309		-.40	-1.10	-5.5	500	200	200	350	350	60
Q310		5.6	4.9	0	750	85	70	400	0	0
Q311		-13	-12.5	-18.5	1.5k	1.5k	5k	10k	6k	3k
Q312		-12	-12.5	-18.5	3k	2.5k	1.5k	1.5k	6k	3k
Q313		-12	-12.5	-18.5	3k	2.5k	1.5k	1.5k	6k	3k
Q314		-12	-12.5	-18.5	2.5k	2.5k	1.5k	1.5k	6k	3k
Q315		-12	-12.5	-18.5	2.5k	2.5k	1.5k	1.5k	6k	3k
Q316		-11	-11	-2.45	500	2.5k	750	100	40	40
Q317		-11	-11	-2.45	500	2.5k	750	100	40	40
Q318		-11	-11	-2.45	500	2.5k	750	100	40	40
Q319		-11	-11	-2.45	500	2.5k	750	100	40	40
	Positive Output Amp.									
Q320		-1.9	-1.20	0	95	1000	500	45	0	0
Q321		-1.3	-1.8	-15	200	100	130	1000	500	70
Q322		-15.5	-15	0	80	1000	500	45	0	0
Q323		12	12	18	2k	2k	8k	6k	2.5k	10k
Q324		11.5	12.5	18	2.5k	2.5k	2k	2k	2.5k	10k
Q325		11.5	12.5	18	2.5k	2.5k	2k	2k	2.5k	10k
Q326		11.5	12.5	18	2.5k	2.5k	2k	2k	2.5k	10k
Q327		11.5	12.5	18	2.5k	2.5k	2k	2k	2.5k	10k
Q328		11	11	2.40	2.5k	3k	120	10k	40	40
Q329		11	11	2.40	2.5k	3k	120	10k	40	40
Q330		11	11	2.40	2.5k	3k	120	10k	40	40
Q331		11	11	2.40	2.5k	3k	120	10k	40	40

(1) All resistance in ohms were made on the X10 Scale.

(2) All resistance in K ohms were made on the X1000 Scale.

TABLE 4-1. VOLTAGE AND RESISTANCE

(FRONT END) MODEL 110

TRANSISTOR	CIRCUIT	VOLTAGE E	VOLTAGE B	VOLTAGE C	RESISTANCE EMITTER		RESISTANCE BASE		RESISTANCE COLLECTOR	
	OSC									
Q1		-2.8	-3.1	-5.4	450	85	40	750	22	75
Q2		-.65	-2.5	-2.5	250	4k	450	850	85	250
Q3		-.30	0	0	2.7k	100	12.5k	350	19k	-
Q4		-.30	.35	-.45	2.7k	90	3.3k	300	6.5k	-
Q5		-.30	-.75	-5.4	42	75	90	450	2.7k	
Q6		-.30	-.65	-5.4	3.3k	90	80	350	-	75
Q7		-.6	-.15	2.15	200	1.2k	800	42	180	140
Q8		-.6	2.6	5.2	200	1.2k	500	250	85	180
	Input Amp.									
Q9		-.80	-.15	5.0	120	2.5k	200	1.3k	95	50
Q10		-.30	-.70	-.45	18	17	43	40	500	90
	Sync Output Amp.									
Q11		5.4	5.2	0.	2.8k	18	11	300	0	0
Q12		-.35	.40	2.45	14	300	11k	40	250	200
Q13		-5.5	-5.4	-.35	43	80	350	110	600	65
	Gating Amp.									
Q14		-.15	.5	2.65	38	500	3.5k	100	250	200
Q15		-.15	-1.25	5.4	38	500	6.5k	200	150	100
Q16		-1.35	-1.35	-.40	60	90	350	180	200	250
	Delay One Shot									
Q17		-.25	-.10	3.4	130	1.6k	42k	300	37	100
Q18		-.20	-.30	5.4	130	1.6k	110	55	44	3
Q19		3.5	3.4	0	1.5k	20	15	170	0	0
Q20		2.6	3.2	5.4	95	190	95	46	46	3
Q21		-.45	.25	2.15	37	500	2.2k	12	400	100
	Mixing Ckt.									
Q22		-.15	.55	1.25	37	500	4.2k	40	350	100
Q23		1.45	1.25	5.4	130	500	400	55	45	3
Q24		1.45	2.10	5.4	130	500	400	55	45	3
Q25		-.35	-.80	-.60						
	Width One Shot									
Q26		-.60	-.05	1.55	150	1.7k	4.2k	350	500	250
Q27		-.60	-.45	5.5	150	1.7k	120	55	45	3
Q28		2.7	1.55	0	1.5k	18	14	300	0	0
Q29		2.70	2.05	5.5	120	800	500	95	45	3
Q30		.15	.35	4.1	18	18	40	120	70	180

* All switches in position shown on schematic with Verniers fully clockwise.

POWER SUPPLY MODEL 110

TRANSISTOR	CIRCUIT	VOLTAGE E	VOLTAGE B	VOLTAGE C	RESISTANCE EMITTER		RESISTANCE BASE		RESISTANCE COLLECTOR	
Q501	+25v adj.	10.8	10	.40	4k	75	500	200	9k	50
Q502	+5.5v sup.	-.30	.40	5.5	3	750	9k	50	44	3
Q503	+25v sup.	0	-.30	-12	0	0	4	1k	3	45
Q505	+5.5v adj.	5.4	6	8.2	3	500	300	300	170	500
Q506	+5.5v sup.	5.4	5.4	0	44	3	3	400	0	0
Q508	-25v sup.	-25	-25	-37.5	100	110	140	300	120	130
Q509	-5.5v sup.	-25	-25	-20.5	140	300	9.5k	300	100	120
Q510	-25v adj.	-14.5	-15	-25	2.5k	28	750	300	9.5k	300
Q511	-5v adj.	-4.8	-5.4	-10.5	500	65	300	750	300	350
Q512	-5.5v sup.	-5.4	-4.8	-.45	42	80	500	65	14	80

TABLE 4-1. VOLTAGE AND RESISTANCE

BASELINE OFFSET MODEL 110

TRANSISTOR	CIRCUIT	VOLTAGE E	VOLTAGE B	VOLTAGE C	RESISTANCE EMITTER		BASE		COLLECTOR	
Baseline Offset Pos. Pulse										
Q332		-1.25	-1.70	-20	50k	7k	12k	5k	10k	6.5k
Q333		-1.25	-1.80	-25	50k	7k	12k	100k	10k	250
Q334		-23.5	-23	25	3.5k	-	4k	9k	6k	50k
Q335		-25	-25	-23.5	100	80	10k	250	3.5k	-
Q336		25.5	25	-2	150	100	300	30k	4k	50k
Q337		-23	-22.5	-2	4k	9k	2k	2k	3.5k	50k
Q338		-23	-23	-2	4k	9k	2k	2k	3.5k	-
Baseline Offset Auxiliary Power Supply positive pulse										
Q339		-.10	.40	25	5k	7k	-	120	200	13k
Q340		25	25	21	80	45	200	15k	30k	110
Q341		20	21	25	2.5k	10k	25k	100	80	45
Q342		10.8	10	-15	120	10k	400	13k	1000	1000
Baseline Offset Neg. Pulse										
Q343		-2.75	-.75	21	6k	50k	3.5k	13k	6k	10k
Q344		-2.75	-1.10	25	6k	50k	11k	30k	200	50k
Q345		25	25	23	80	42	200	50k	-	3.5k
Q346		23.5	23	-25.5	-	3.5k	6.5k	4k	12k	6.5k
Q347		-25.5	-26	-2	170	150	2.8k	350	3.5k	5k
Q348		23	22.5	-2	6.5k	4k	2k	2k	4k	4.5k
Q349		23	22.5	-2	6.5k	4k	2k	2k	4k	4.5k
Baseline Offset Auxiliary Power Supply negative pulse										
Q350		.20	-.35	-23.5	1.8k	1.7k	100	-	14k	4k
Q351		-24	-23.5	.20	2k	500	13k	4k	1.8k	1.7k
Q352		-25	-24	-20	6.5k	200	2k	500	6k	3k
Q353		-11.2	-10.5	14	1000	100	7.5k	400	1000	1000

4.5 SPECIFICATION VERIFICATION

The following detailed test was performed on this instrument, just prior to shipment, to confirm published specifications. Before the test was conducted the instrument was aged for a 24 hour period and had undergone rigid examination for workmanship and appearance.

This test should be performed after every 200 hours of operation to confirm calibration status. Recalibrate and/or troubleshoot the instrument if the specifications are not verifiable.

4.5.1 Equipment Required

a. Oscilloscope, Hewlett-Packard 175A or equivalent (general purpose).

b. Oscilloscope, Hewlett-Packard 185B or equivalent (high-band pass).

c. Two 50-ohm terminations.

d. One 20-db coaxial attenuator.

e. Trigger generator (40 mc).

4.5.2 Repetition Rate

4.5.2.1 Oscillator Timing:

a. Set PULSE DELAY to 0.05 μs. VERNIER ccw.

b. Set PULSE WIDTH to 0.05 μs, VERNIER ccw.

c. Set TRANSITION TIME to 10 ns, VERNIERS ccw.

d. Set ATTENUATORS to 10v, VERNIERS cw.

e. Terminate outputs into 50Ω load.

f. Sync scope from Neg. sync output.

g. View pos. output pulse and follow the panel control settings in Table 4-2.

4.5.2.2 Jitter:

a. Set controls as in 4.5.2.1 (a through e) above. Internally sync oscilloscope with + Int.

b. Set REPETITION RATE CONTROLS for 10 mc operation.

c. Set Sweep Speed to 0.1 μs/cm.

d. View pos. output pulse terminated into 50Ω load. One pulse should appear for each .835 cm. View the 10th pulse and expand sweep to 10 ns/cm. The leading edge jitter should be less than 0.05, (0.05%).

4.5.2.3 Stability: Leave setup as in paragraph 4.5.2.2. Vary input voltage from 105v ac to 125v ac. The shift should be less than 1 cm (1%).

4.5.2.4 External Triggering: Apply a ±1.5v signal from trigger generator to the external trigger input jack and verify that instrument can be slaved up to 40 mc with repetition rate control in both EXT. + and EXT. - positions.

4.5.2.5 Sync Pulse:

a. Set DELAY and WIDTH to minimum.

b. View Negative sync pulse output into 50Ω load.

c. Sweep REPETITION RATE from 4 mc to 40 mc.

d. Sync Pulse amplitude should be over 2v.

4.5.2.6 External Gate:

a. Set REPETITION RATE at 10 mc.

b. View positive output pulse.

c. Apply a square wave of +3.5v in amplitude to "external gate" input jack with a repetition rate of 100 kc.

TABLE 4-2. REPETITION RATE CALIBRATION VERIFICATION

REP. RATE RANGE	REP. RATE VERNIER	OUTPUT PULSE WIDTH	SCOPE SWEEP SPEED/CM	PULSE SPACING
40 cps	ccw	5 ms	0.1 sec	> 0.25 sec
40 cps	cw	5 ms	10 ms	< 25 ms
400 cps	ccw	0.5 ms	10 ms	> 25 ms
400 cps	cw	0.5 ms	1 ms	< 2.5 ms
4 kc	ccw	50 μs	1 ms	> 2.5 ms
4 kc	cw	50 μs	0.1 ms	< 0.25 ms
40 kc	ccw	5 μs	0.1 ms	> 0.25 ms
40 kc	cw	5 μs	10 μs	< 25 μs
400 kc	ccw	0.5 μs	10 μs	> 25 μs
400 kc	cw	0.5 μs	1 μs	< 2.5 μs
4 mc	ccw	50 ns	1μs	>2.5μs
4 mc	cw	50 ns	0.1μs	<0.25μs
40 mc	ccw	10 ns	0.1μs	>0.25μs
40 mc	cw	10 ns	10 ns	<25 ns

d. Observe that output pulses occur only during negative portion of square wave.

4.5.3 Pulse Delay

4.5.3.1 Delay Timing:

a. Set Positive and Negative ATTENUATORS to 10v, VERNIERS cw.

b. Set TRANSITION TIME to 5 ns, VERNIERS ccw.

c. Set REPETITION RATE to 400 kc, VERNIERS cw.

d. Sync oscilloscope from negative sync output.

e. View the sync pulse and positive pulse output (50Ω termination) simultaneously on dual trace oscilloscope.

f. Follow control settings in Table 4-3.

4.5.3.2 Delay Duty Cycle:

a. Set REPETITION RATE to 100 kc.

b. Set PULSE WIDTH to 0.5 μs, VERNIER to cw.

c. Sync scope from negative sync output with sweep speed of 1 μs/cm.

d. View positive pulse output (50Ω termination).

e. Set DELAY to 5μs, VERNIER ccw. Slowly turn VERNIER cw and verify that 75% delay duty cycle (7.5 μs) can be attained without circuit failure.

4.5.3.3 Delay Jitter:

a. With controls set as in paragraph 4.5.3.2, (5 μs Delay). Set sweep speed to 0.5 μs/cm and expand to 50 ns/cm.

b. View leading edge of pulse and verify that jitter is less than 0.1 cm (0.1%).

4.5.3.4 Delay Stability: With same setup as paragraph 4.5.3.3, vary input voltage from 105v to 125v and verify that delay change is less than 1 cm (1%).

4.5.4 Pulse Width

4.5.4.1 Pulse Width Timing:

a. Set ATTENUATORS to 10v, VERNIERS to cw.

b. Set TRANSITION TIME to 5 ns, VERNIERS ccw.

c. Set REPETITION RATE to 400 kc, VERNIER cw.

d. Sync Oscilloscope from negative sync output.

e. View the positive pulse output (50Ω termination).

f. Follow control settings on Table 4-4.

4.5.4.2 Pulse Width Stability: With the same setup as paragraph 4.5.3.3 vary line voltage from 150v to 125v and verify that pulse width change is less than 1cm (1%).

4.5.4.3 Pulse Width Duty Cycle:

a. Set REPETITION RATE to 100 kc.

b. Set PULSE DELAY to 0.5 μs, VERNIER cw.

c. Sync scope from negative sync output with sweep speed of 1 μs/cm.

d. View positive pulse output (50Ω termination).

e. Set PULSE WIDTH to 5 μs, VERNIER ccw. Slowly turn VERNIER cw and

TABLE 4-3. DELAY CALIBRATION VERIFICATION

DELAY RANGE	DELAY VERNIER	PULSE WIDTH	REP. RATE	SCOPE SWEEP SPEED CM	DELAY
0.05 μs	ccw	50 ns	400 kc	50 ns	>10 ns
0.05 μs	cw	50 ns	400 kc	50 ns	>50 ns
0.5 μs	ccw	0.5 μs	40 kc	50 ns	<50 ns
0.5 μs	cw	0.5 μs	40 kc	0.1 μs	>0.5 μs
5 μs	ccw	5 μs	4 kc	0.1 μs	<0.5 μs
5 μs	cw	5 ns	4 kc	1 μs	>5 μs
50 μs	ccw	0.05 ms	400 cps	1 μs	<5 μs
50 ns	cw	0.05 ms	400 cps	10 μs	>50 μs
0.5 ms	cw	0.5 ms	400 cps	10 μs	<50 μs
0.5 ms	cw	0.5 ms	40 cps	0.1 ms	>0.5 ms
5 ms	ccw	0.5 ms	40 cps	0.1 ms	<0.5 ms
5 ms	cw	5 ms	4 cps	1 ms	>5 ms
50 ms	ccw	5 ms	4 cps	1 ms	<5 ms
50 ms	cw	5 ms	4 cps	10 ms	>50 ms

TABLE 4-4. WIDTH CALIBRATION VERIFICATION

WIDTH RANGE	WIDTH VERNIER	PULSE DELAY	REP. RATE	SCOPE SWEEP SPEED CM	WIDTH
0.05 μs	ccw	50 ns	400 kc	50 ns	<10 ns
0.05 μs	cw	50 ns	400 kc	50 ns	>50 ns
0.5 μs	ccw	0.5 μs	40 kc	50 ns	<50 ns
0.5 μs	cw	0.5 μs	40 kc	0.1 μs	>0.5 μs
5 μs	ccw	5 μs	4 kc	0.1 μs	<0.5 μs
5 μs	cw	5 μs	4 kc	1 μs	>5 μs
50 μs	ccw	50 μs	400 cps	1 μs	<5 μs
50 μs	cw	50 μs	400 cps	10 μs	>50 μs
0.5 ms	ccw	0.5 ms	400 cps	0.1 ms	<50 μs
0.5 ms	cw	0.5 ms	40 cps	0.1 ms	>0.5 ms
5 ms	ccw	5 ms	40 cps	1 ms	<0.5 ms
5 ms	cw	5 ms	40 cps	1 ms	>5 ms

verify that 75% WIDTH duty cycle (7.5μs) can be attained without circuit failure.

4.5.4.4 Pulse Width Jitter:

a. Adjust pulse width for 5 μs and Rep. Rate for 100 kc. Sync scope on +Int. Look at positive output. Set sweep speed to 0.5 μs/cm and expand to 50ns/cm.

b. View lagging edge of pulse and verify that jitter is less than 0.1 cm (0.1%).

4.5.5 Main Pulse Output

4.5.5.1 Transition Time:

a. View POSITIVE PULSE terminated into 50 ohms.

b. Check the upper and lower end of each range at the transition time control as shown in Table 4-11.

TABLE 4-5. TRANSITION TIME VERIFICATION

Frequency	Pulse Width	Range	Leading Edge Control		Trailing Edge Control		Sweep Speed
			Max. ccw	Max. cw	Max. ccw	Max. cw	Min. Max.
100 kc	0.5 μs	5 ns	≤6 ns	>50 ns	≤6ns	>50 ns	2ns/cm;20/cm
10 kc	5 μs	0.05 μs	<50 ns	>500 ns	<50 ns	>500 ns	.05μs/cm;.5μs/cm
1 kc	50 μs	0.5 μs	<0.5 μs	>5 μs	<.05 μs	>5 μs	.1μs/cm;1μs/cm
100 cps	500 μs	5 μs	<5 μs	>50 μs	<5 μs	>50 μs	1μs/cm;10μs/cm
10 cps	5 ms	.05 ms	<.05 ms	>0.5 ms	<.05 ms	>0.5 ms	10μs/cm;0.1ms/cm

On pulse width, use vernier ccw for minimum rise measurement and vernier cw for maximum rise measurement.

6 ns rise time must be measured on sampling type oscilloscope.

c. View negative pulse terminated into 50 ohms.

d. Repeat step b above.

4.5.5.2 Output Wave Shape:

a. Set REPETITION RATE for 100 kc.

b. Set PULSE DELAY for 0.2 μs.

c. Set PULSE WIDTH for 0.2 μs.

d. Set TRANSITION TIMES for 6 ns.

e. Set ATTENUATORS for 10v.

f. Connect positive pulse output through a 20 db (10:1) coaxial attenuator into a 50Ω load.

g. Set negative attenuator to 0.3v.

h. View voltage across load with high bandpass oscilloscope (HP185B or equivalent)

i. Set sweep speed 50 ns/cm.

j. Set vertical sensitivity 0.2v/cm (10:1 attenuator makes 2v/cm effective) See Figure 4-5.

k. Verify that amplitude is 5 cm±1/4cm (5%).

l. Verify that pulse aberrations are less than 0.2 cm (4%).

m. Set sweep speed to 2 ns/cm.

n. View leading edge and verify that rise time from 10% to 90% amplitude points is less than 6 nanosec (3cm).

0. View lagging edge and verify that decay time from 90% to 10% amplitude points is less than 6 nanosec (3cm).

p. Set positive attenuator to 0.3v. Set negative attenuator to 10 volts. Connect negative pulse output through 20db (10:1) attenuator to 50 ohm load.

q. Repeat steps h through p.

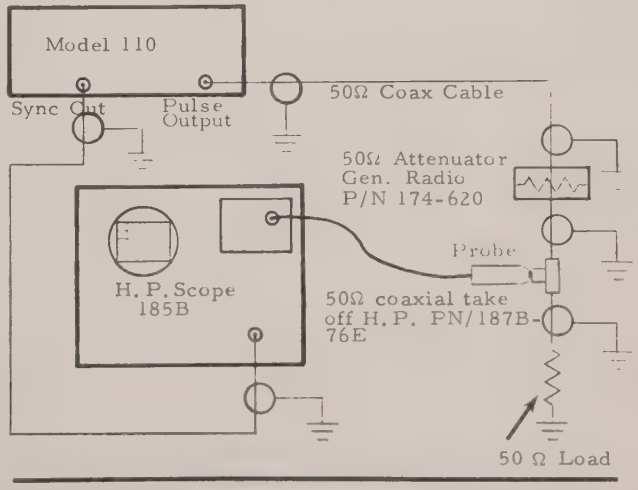
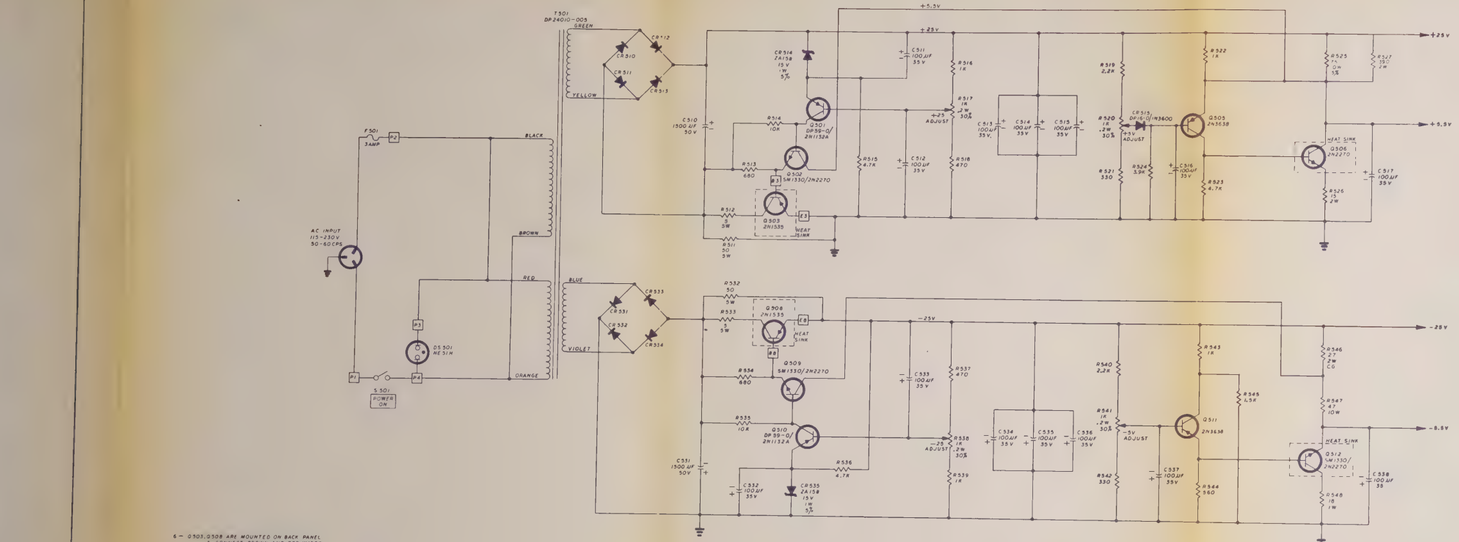


Figure 4-5. Scope Interconnections for Waveform Verification.

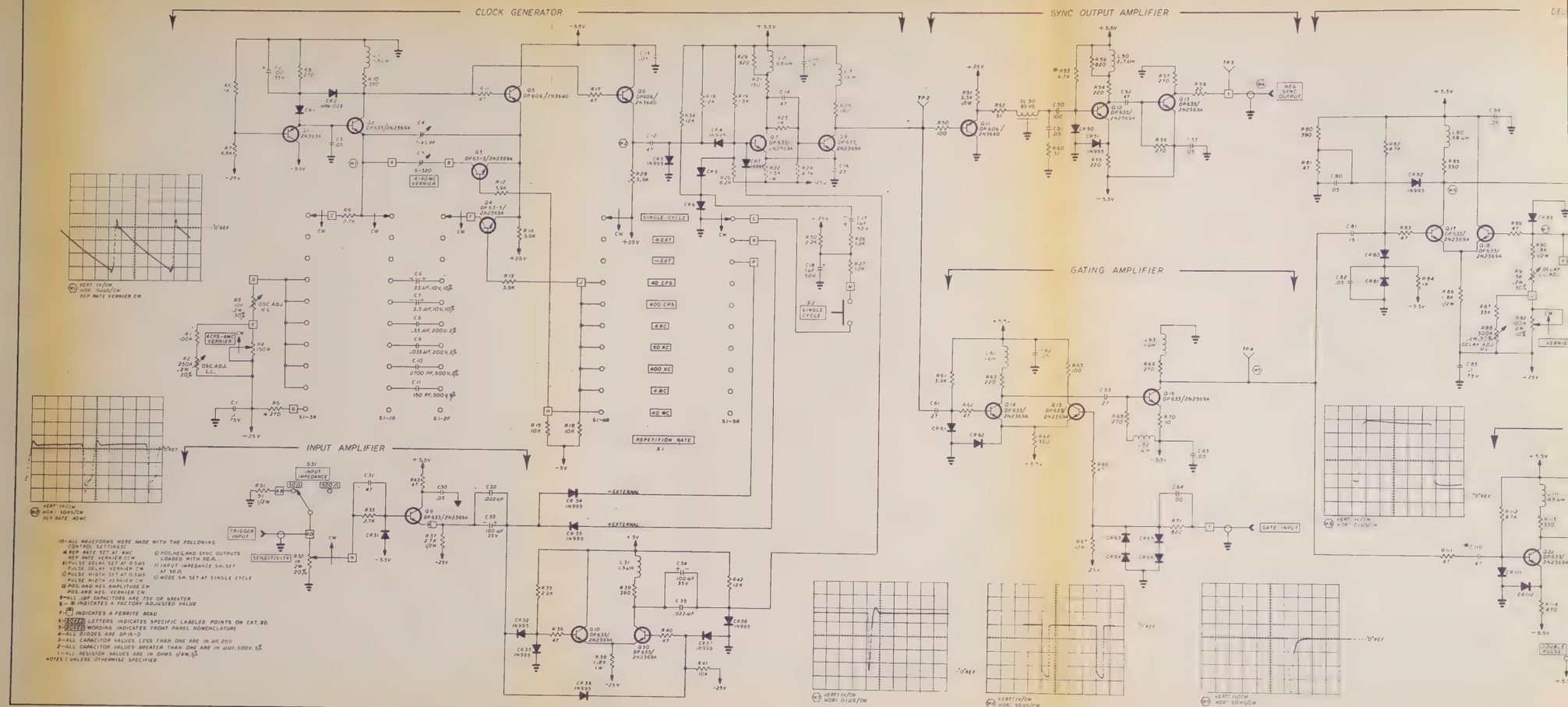


6 — Q503, Q508 ARE MOUNTED ON BACK PANEL
3 — CONNECT BROWN AND RED WIRES
2 — BREAK CONNECTION BETWEEN BROWN AND ORANGE WIRES
1 — BREAK CONNECTION BETWEEN BLACK AND RED WIRES
FOR 230 VAC OPERATION
5 — T501 IS SHOWN CONNECTED FOR 115 VAC OPERATION
4 — BOX(E) = LETTERS AND/OR NUMBERS INDICATE SPECIFIC POINTS ON CIRCUIT BOARD
3 — (P,T,E,D) = MORDING INDICATES FRONT PANEL NOMENCLATURE
2 — ALL DIODES ARE DP31-1/1N4002
1 — ALL RESISTORS ARE 1/2W, 5% UNLESS OTHERWISE SPECIFIED

REFERENCE DESIGNATIONS		
D1501	D1501	
E1501	E1501	
T1501	T1501	
F1501	F1501	
Q1501	Q1512	Q1504, 1507
CR1510	CR1533	CR1511-1530
C1510	C1539	C1511-1530
S1501	R1544	R1502-1526, 1531-1537, 1539-1543, 1545-1547
FIRST USED	LAST USED	OMITTED

REVISIONS			
ONE A SEE DWG 70.40000-03			

SCHEMATIC — POWER SUPPLY
MODEL 110A & 110P
HEWLETT-PACKARD
40000/33


CLOCK GENERATOR
SYNC OUTPUT AMPLIFIER
GATING AMPLIFIER
INPUT AMPLIFIER
SINGLE CYCLE
+EXT
−EXT
40 CPS
400 CPS
4 KC
40 KC
400 KC
4 MC
40 MC
REPETITION RATE
S1
S2 SINGLE CYCLE
4CPS-4MC VERNIER
OSC ADJ H.L.
OSC ADJ L.L.
5-320 4-40MC VERNIER
INPUT IMPEDANCE
50Ω
100Ω
TRIGGER INPUT
SENSITIVITY
−EXTERNAL
+EXTERNAL
NEG SYNC OUTPUT
GATE INPUT
DELAY ADJ
VERNIER
VERT: 1V/CM
HOR: 50NS/CM
REP RATE 40MC
VERT: 1V/CM
HOR: 0.1US/CM
VERT: 1V/CM
HOR: 50NS/CM
VERT: 1V/CM
HOR: 0.1US/CM
VERT: 1V/CM
HOR: 50NS/CM
0 REF
1. ALL WAVEFORMS WERE MADE WITH THE FOLLOWING CONTROL SETTINGS:
A REP RATE SET AT 4MC
REP RATE VERNIER CCW
B PULSE DELAY SET AT 0.5US
PULSE DELAY VERNIER CW
C PULSE WIDTH SET AT 0.5US
PULSE WIDTH VERNIER CW
D POS. AND NEG AMPLITUDE CW
POS. AND NEG. VERNIER CW
E POS,NEG,AND SYNC OUTPUTS LOADED WITH 50Ω.
F INPUT IMPEDANCE SW. SET AT 50Ω
G MODE SW. SET AT SINGLE CYCLE
2. ALL 1UF CAPACITORS ARE 75V OR GREATER
3. ⊕ INDICATES A FACTORY ADJUSTED VALUE
4. INDICATES A FERRITE BEAD
5. BOXED LETTERS INDICATES SPECIFIC LABELED POINTS ON CRT, BD.
6. BOXED WORDING INDICATES FRONT PANEL NOMENCLATURE
7. ALL DIODES ARE DP16-0
8. ALL CAPACITOR VALUES LESS THAN ONE ARE IN UF, 25V
9. ALL CAPACITOR VALUES GREATER THAN ONE ARE IN UUF, 500V, 5%
10. ALL RESISTOR VALUES ARE IN OHMS 1/4W, 5%
NOTES: UNLESS OTHERWISE SPECIFIED

AY ONE-SHOT

WIDTH ONE-SHOT

MIXING CIRCUIT

DELAYED OUTPUT

DELAYED PULSE

TRIGGER OUTPUT

TO OUTPUT AMPLIFIER TPB (DWG.40000Q-131)

PULSE DELAY S80

S121 PULSE WIDTH

VERNIER

MODE

SINGLE PULSE

NOTE: 50 MS RANGE NOT USED ON MODEL 110

VERT: 0.5V/CM HOR: 0.1µS/CM

VERT: 1V/CM HOR: 5.1NS/CM REP RATE: 40MC

VERT 1V/CM HOR 0.1µS/CM

VERT: 1V/CM HOR: 0.1µS/CM

VERT: 1V/CM HOR: 50NS/CM REP RATE: 40MC

VERT: 1V/CM HOR: 0.1µS/CM

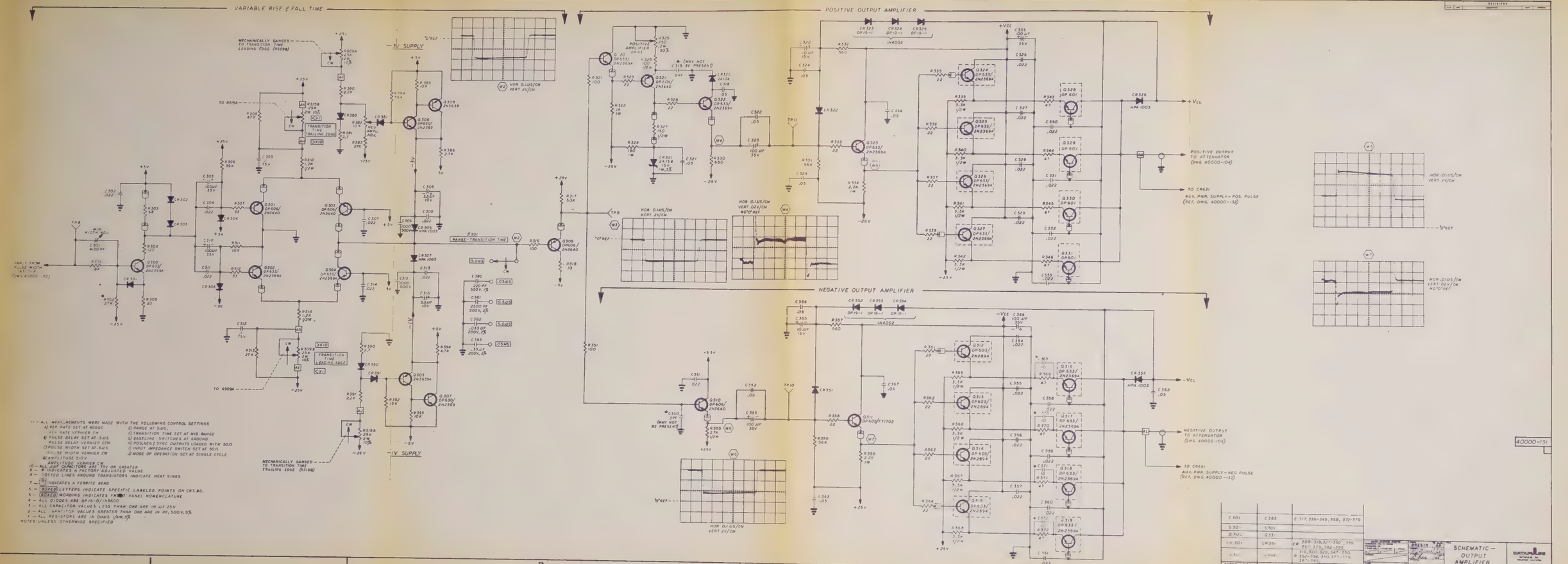
VERT: 1V/CM HOR: 0.1µS/CM

C	C121	5,3-30,32-79,81-110,112-120
L	L121	L4-30,32-49,51-60,64-79 82-110,113-120
Q	Q30	
CR	CR124	CR8-30,39-49,52-60,67-79 88-110,117-120,125
C	C133	C 5-19,35-49,54-60,66-79 83-109,114,116-120,124
R	R 18	R44-49,72-79 103-110
FIRST USED	LAST USED	OMITTED
REFERENCE DESIGNATIONS		

SCHEMATIC — FRONT END MODEL 110A

DATAPULSE INCORPORATED

40000-130


VARIABLE RISE & FALL TIME
POSITIVE OUTPUT AMPLIFIER
NEGATIVE OUTPUT AMPLIFIER
MECHANICALLY GANGED TO TRANSITION TIME LEADING EDGE (R309A)
MECHANICALLY GANGED TO TRANSITION TIME TRAILING EDGE (R315A)
TRANSITION TIME LEADING EDGE
TRANSITION TIME TRAILING EDGE
+5V SUPPLY
-5V SUPPLY
+V SUPPLY
-V SUPPLY
TO R309A
TO R315A
FROM PULSE WIDTH AMPL (SHT 2, DWG 40000-130)
RANGE-TRANSITION TIME
POSITIVE OUTPUT TO ATTENUATOR (DWG 40000-104)
TO CR621 AUX. PWR. SUPPLY-POS. PULSE (REF. DWG. 40000-152)
NEGATIVE OUTPUT TO ATTENUATOR (DWG 40000-104)
TO CR661 AUX. PWR. SUPPLY-NEG PULSE (REF. DWG. 40000-153)
HOR .01 US/CM VERT 2V/CM
HOR .01 US/CM VERT .02V/CM NO "0" REF
HOR .01 US/CM VERT 2V/CM NO "0" REF
HOR .01 US/CM VERT 2V/CM
"0" REF
TP8
TP9
TP10
TP11
(MAY NOT BE PRESENT)
11 - ALL MEASUREMENTS WERE MADE WITH THE FOLLOWING CONTROL SETTINGS
A) REP RATE SET AT 400KC
B) AMPLITUDE VERNIER CW
C) PULSE DELAY SET AT .5 US
PULSE DELAY VERNIER CCW
D) PULSE WIDTH SET AT .5 US
PULSE WIDTH VERNIER CW
E) AMPLITUDE 5 VOLTS
E) RANGE AT 5 VOLTS
F) TRANSITION TIME SET AT MID RANGE
G) BASELINE SWITCHES AT GROUND
H) POS./NEG. SYNC OUTPUTS LOADED WITH 50 Ω
I) INPUT IMPEDANCE SWITCH SET AT 50 Ω
J) MODE OF OPERATION SET AT SINGLE CYCLE
10 - AMPLITUDE VERNIER CW
9 - ALL .1UF CAPACITORS ARE 75V OR GREATER
8 - ❖ INDICATES A FACTORY ADJUSTED VALUE
7 - DOTTED LINES AROUND TRANSISTORS INDICATE HEAT SINKS
6 - INDICATES A FERRITE BEAD
5 - BOXED LETTERS INDICATE SPECIFIC LABELED POINTS ON CRT. BD.
4 - BOXED WORDING INDICATES FRONT PANEL NOMENCLATURE
3 - ALL DIODES ARE DP 19-01/IN3600
2 - ALL CAPACITOR VALUES LESS THAN ONE ARE IN μF 75V
1 - ALL CAPACITOR VALUES GREATER THAN ONE ARE IN PF, 500 V, 5%
NOTES: ALL RESISTORS ARE IN OHMS 1/4W, 5% UNLESS OTHERWISE SPECIFIED
C 301 C 383 C 317, 336-349, 368, 372-379
S 301- S 101-
Q 301- Q 331-
CR 301 CR 391- CR 308-319, 327-350, 355, 357-376, 382-389
- - CR 320-326, 351-354, 377-379, 387-389
FIRST USED LAST USED REFERENCE DESIGNATIONS OMITTED
SCHEMATIC — OUTPUT AMPLIFIER MODEL 110A
DATAPULSE INCORPORATED
40000-131

REVISIONS				
NO.	ZONE		DATE	APPROVED
1015	A	CORRECTED ERRORS & RELEASED	10 JAN 65	
1045	B	SEE DWG EOJ4000-104	24 SEPT 65	

S410-REAR

S410-FRONT

AMPLITUDE WITH 50Ω TERMINATION

INPUT FROM OUTPUT AMP

A10

R411 51

R413 51

POSITIVE 10 VOLTS

R410B CW

R410A CW

50Ω BRIDGE "T" PAD

CASE OF BRIDGE "T" PAD

10

30

03

10

10

03

10

R414 27 R416 27 R417 24 R419 24 R420 27 R422 27 R423 24 R425 24 R426 27 R428 27

R415 33 R418 36 R421 33 R424 36 R427 33

POS. OUTPUT

FROM BASELINE OFFSET— POS. PULSE

S440-REAR

S440-FRONT

AMPLITUDE WITH 50Ω TERMINATION

INPUT FROM OUTPUT AMP

A11

R441 51

R443 51

NEGATIVE 10 VOLTS

R440B CW

R440A CW

CASE OF BRIDGE "T" PAD

10

30

03

10

10

03

10

R444 27 R446 27 R447 24 R449 24 R450 27 R452 27 R453 24 R455 24 R456 27 R458 27

R445 33 R448 36 R451 33 R454 36 R457 33

NEG. OUTPUT

FROM BASELINE OFFSET NEG. PULSE

40000-104 B

1 BOXED LETTERS INDICATE SPECIFIC LABELED POINTS ON CKT BD.
2 BOXED WORDING INDICATES FRONT PANEL NOMENCLATURE.
1 ALL RESISTOR VALUES ARE IN OHMS, 2W, 5%.
NOTES UNLESS OTHERWISE SPECIFIED

S410 C410 R410	S440 C440 R458	S411-439 C410-440 R429-439, 412, 442
FIRST USED	LAST USED	OMITTED

REFERENCE DESIGNATIONS

DRAWN	10 SEP 64	
TRACED		
CHECKED		
ENGR APPR.		
MFG APPR.		
QUAL. ENGR		
PROJ. ENGR		

SCHEMATIC- ATTENUATOR MODEL 110A MODEL 110P

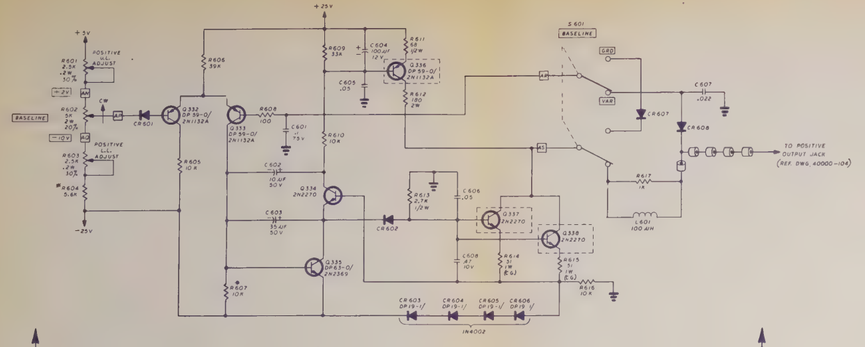
NONE DECODE 15233

40000-104 B

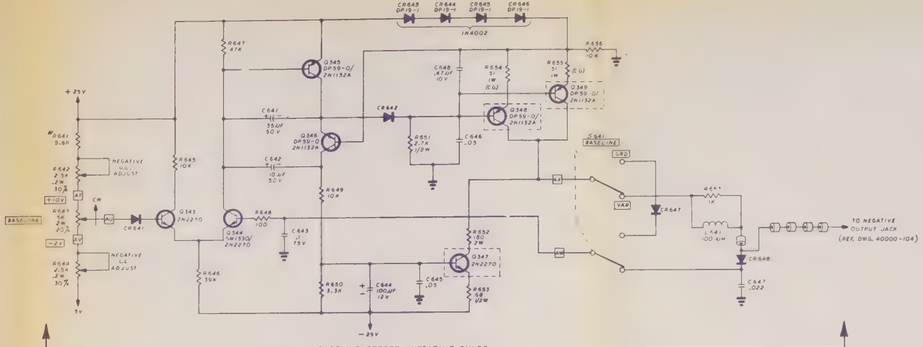
SIZE D

SCALE NONE

SHEET 1 OF 1

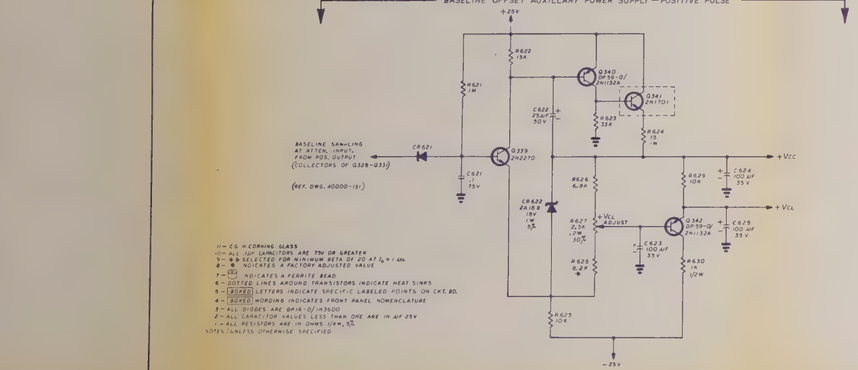


BASELINE OFFSET — POSITIVE PULSE



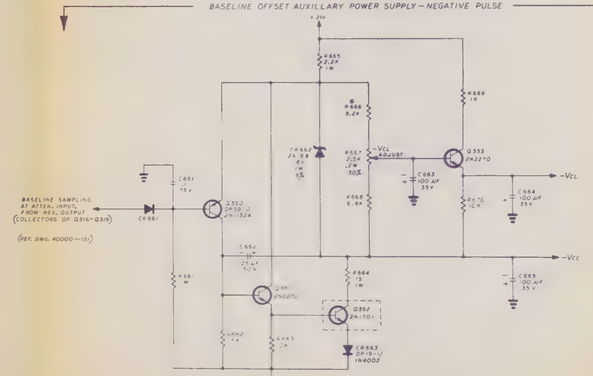
BASELINE OFFSET — NEGATIVE PULSE

BASELINE OFFSET AUXILLARY POWER SUPPLY — POSITIVE PULSE



1 = CG = CORNING GLASS
10 = ALL 1UF CAPACITORS ARE 75V OR GREATER
9 = ⑨ SELECTED FOR MINIMUM BETA OF 20 AT I_C = 1 MA
8 = ⑧ INDICATES A FACTORY ADJUSTED VALUE
7 = (FB) INDICATES A FERRITE BEAD
6 = DOTTED LINES AROUND TRANSISTORS INDICATE HEAT SINKS
5 = BOXED LETTERS INDICATE SPECIFIC LABELED POINTS ON CKT. BD.
4 = BOXED WORDING INDICATES FRONT PANEL NOMENCLATURE
3 = ALL DIODES ARE DP18-0/IN3600
2 = ALL CAPACITOR VALUES LESS THAN ONE ARE IN UF 25V
1 = ALL RESISTORS ARE 1/4W, 5%
NOTES: UNLESS OTHERWISE SPECIFIED

BASELINE OFFSET AUXILLARY POWER SUPPLY — NEGATIVE PULSE



S601	S641	S632-640
L601	L641	L602-640
Q332	Q353	
CR601	CR603	CR639-640,643,649-660
C601	C644	C602-603,605-606,632-639
R601	R670	C604-605,611-614,638-639
FIRST USED	ASSY USED	1W TYP

REFERENCE DESIGNATIONS

DRAWN		SCHEMATIC — BASELINE OFFSET AUXILLARY POWER SUPPLY — MODEL 10A	DATAPULSE INCORPORATED
CHECKED			
ENGR APPR			
MFG APPR			
QUALITY			
SIZE	CODE IDENT NO.		40000-132
D	80009		
SCALE		SHEET	

40000-132

DATAPULSE
DIVISION OF DATAPULSE INCORPORATED

SERVICE BULLETIN NO. 1-65

SEMICONDUCTOR REPLACEMENTS

(Applicable to all Datapulse Models except the Model 100 & 102)

Datapulse makes extensive use of house labeled semiconductors, superseding or used in place of commercial equivalents. In most cases, these are procured against relaxed or actual commercial equivalent specifications, and commercial equivalents as listed below may, therefore, be used as replacements.

	DATAPULSE TYPE NO.*	DATAPULSE PART NO.	COMMERCIAL EQUIVALENT
Diodes:	DP16-0	22164-000	1N3600
	DP16-1	22164-001	1N3604
	DP19-0	22194-000	1N2070
	DP19-1	22194-001	1N4002
	DP19-6	22194-006	1N2071
Transistors:			
	DP43-0	22435-000	2N984
	DP46-0	22465-000	2N964A
	DP46-1	22465-001	None**
	DP59-0	22595-000	2N1132A
	DP60-0	22605-000	2N2411
	DP60-1	22605-001	None**
	DP60-2	22605-002	2N2904
	DP60-3	22605-003	2N2894
	DP60-4	22605-004	2N3209
	DP60-5	22605-005	FT1702
	DP60-6	22605-006	2N3640
	DP63-0	22635-000	2N2369 or 2N2501
	DP63-1	22635-001	None**
	DP63-2	22635-002	None**
	DP63-3	22635-003	2N2369A

*Some earlier publications show Type No. without the dash.

**DP46-1 is selected from 2N2964A for high Beta.
DP60-1 is selected from 2N2894 for high V_{eco}.
DP63-1 is selected from 2N2218 for secondary breakdown characteristics.
DP63-2 is selected from 2N914 for tighter Beta tolerance.

Replacements for these items should be procured from Datapulse.

10/12/65

WARRANTY

Datapulse Incorporated warrants each instrument of its manufacture to be free from defects in material and workmanship. Our obligation under this Warranty is limited to servicing or adjusting any instrument returned to our factory for that purpose, and to making good at our factory any part or parts thereof except tubes, transistors, fuses or batteries which shall, within one year after making delivery to the original purchaser, be returned to us with transportation charges prepaid, and which our examination shall disclose to our satisfaction to have been thus defective.

Instruments returned under this Warranty will not be accepted at the Datapulse plant without prior authorization by a Datapulse representative or by the service manager of Datapulse Incorporated.

Datapulse Incorporated reserves the right to make changes in design at any time without incurring any obligation to install same on units previously purchased.

This Warranty is expressly in lieu of all other obligations or liabilities on the part of Datapulse Incorporated and Datapulse Incorporated neither assumes nor authorizes any other person to assume for them any other liability in connection with the sales of Datapulse Incorporated instruments.

INSTRUMENT CERTIFICATION

MODEL 110A

Serial Number 110-A 413

1. REPETITION RATE

   a. Internal
      Coverage: 4 cps to 40 Mc
      Vernier: No holes

   b. External
      Triggers from ± 1.5v pulses with rise time less than 20 nanosec and duration greater than 20 nanosec.

   c. Gated Operation
      Signals more positive than +3.5v block ou output.

2. SYNC OUTPUT

   Sync Amplitude greater than 2v into 50Ω from 4 cps to 40 Mc.

3. PULSE DELAY

   Coverage: 10 nanosec advance to 50 millisec delay.
   Vernier: No holes.

4. PULSE DURATION

   Coverage: 10 nanosec to 5 millisec.
   Vernier: No holes.

5. MAIN PULSE OUTPUT

   Amplitude is greater than 10v into 50 ohms.
   Positive Pulse
   Negative Pulse

   Transition Time:
   Coverage: 6 nanosec to 0.5 millisec
   Leading Edge
   Lagging Edge

   Vernier (No Holes):
   Leading Edge
   Lagging Edge

   Waveform aberrations are less than ±3% at amplitudes greater than 3v.

   Positive Pulse
   Negative Pulse

6. DOUBLE PULSE

   Coverage: 4 cps to 20 Mc
   Positive Pulse
   Negative Pulse

7. DC OFFSET

   Adjustable from +2v to -10v on positive pulse.
   Adjustable from -2v to +10v on negative pulse.

I certify that this instrument meets the above specifications.

12/11/65
Date

Test Inspector

Q. C. ACCEPTANCE	
INSPECTOR	DATE

RECORD OF PRINTING AND REVISIONS

PUBLICATION: INSTRUCTION MANUAL-MODEL 110 A Date of Printing: 6-25-65 (Initial)

Serial No. Effectivity: 001 through 300

REVISION	DATE	CHANGE OR ADDITION
A Printed: 10-1-65 Ser. No. 301 & Subsequent	8/3/65	P. 2-7, Para. 2.3.7, second to last sentence. Word "transistor" inserted in blank.
	8/3/65	P. 2-8, Figure 2-12a: "+6V" moved up 1/2 space, "-0V" moved down 1 space. Figure 2-12b: "-+6V" moved up 1 space, "-0V" moved down 1 space.
	8/3/65	P. 2-9, Para. 2.3.8.1, second paragraph, no. a: Word "disired" changed to "desired".
	8/3/65	P. 2-10, para 2.4.2, last sentence: Word "positive" changed to "negative".
	8/3/65	P. 3-1, para. 3.1, third sentence: "50 nanosec" changed to "85 nanosec".
	8/3/65	P. 3-1, para. 3.2.3, second paragraph, second sentence: "Q27" changed to "CR124".
	8/3/65	P. 3-2, para. 3.2.8, second paragraph, second sentence: "-24 volts" changed to "-25 volts".
	8/3/65	P. 3-5, Figure 3-3, left side of diagram: no "$-V_2$" added.
	8/3/65	P. 4-14, Table 4-3, seventh Scope Sweep Speed CM down: " 1 ns" changed to " 1 μs".
	8/3/65	P. 4-15, Figure 4-5, 50 ohm load properly identified.
	9/29/65	P. 3-2, Para. 3.2.7, revised to reflect changes incorporated in Model 110A.
	9/29/65	P. 3-8 Para. 3.2.9, revised to reflect changes incorporated in Model 110A.
	9/29/65	P. 3-9, Figure 3-9, revised to reflect circuitry of 110A.
	9/29/65	Section V, Parts List, omitted from printing, pending revision for 110A.

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